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THE Petroleum Engineer

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A Magazine of Methods for Operating Men

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The Course of Oil

By K. C. SCLATER

States Refute Need for Cole Bill

Governors of the various oil producing states and members of the state commissions in charge of oil regulation emphatically refuted the need for the Federal Oil Control bill in statements before the Cole Committee when it resumed its hearings on February 6th in Washington. The following excerpts taken from the testimony disclose, among other things, the strong stand taken on states rights and the plain speaking with regard to price, conservation, and economic waste.

Governor Payne Ratner of Kansas: "The accumulated experience of ten years of waste-prevention has resulted in the establishment of a state agency fully prepared to cope with any of the numerous problems arising out of conservation. . . . If some states, lacking experience as major oil producing states, have not enacted adequate conservation laws, the states which have should not be penalized by unnecessary federal regulation . . . and I submit storage of crude oil above ground is economic waste."

Governor Leon C. Phillips of Oklahoma: "There are no new conservation principles in this bill; it merely incorporates principles discovered by the oil producers themselves. By its terms, the bill is an unqualified enforcement of the methods and practices invoked by the oil producing states in their conservation laws and recommended by the Interstate Oil Compact Commission. It omits, however, certain well-founded principles of conservation which are embodied in the state laws."

Price, Conservation, and Waste

Warwick M. Downing of Denver, Colorado, chairman of the Colorado Gas Commission: "Nothing more forcibly illustrates the lack of understanding at Washington than the assertion so often made, that the price of crude is not an element of Conservation, and that price must always be 'taboo' among Conservancy officials. . . .

"Petroleum is perhaps the only commodity where price is essential in connection with governmental regulation. A price that results in waste of petroleum is necessarily destructive to national welfare; and a price made too high by reason of excessive curtailment is likewise opposed to the public interest. . . .

"However, as respects conservation, a fair price as distinguished from a price too high or too low, is essential for the following four principal reasons:

"1. A cheap price means actual, important physical waste.

"2. A cheap price brings petroleum unduly into competition with coal, whereby the commodity of greater importance is utilized, whereas coal would answer the same purpose.

"3. A fair price is necessary to conserve our present oil reserves, especially the stripper wells.

"4. A fair price is necessary to sustain development costs which are an essential prerequisite to the continuance of our petroleum reserves and to true conservation."

Hiram M. Dow, of New Mexico, a member of the Interstate Oil Compact Commission: "Price also operates to produce waste in a more positive manner. Before proration, the price of crude oil was determined by supply and demand. In the State of New Mexico production in excess of demand is prohibited by Statute as waste, and the Conservation Commission is obligated to curtail the supply when it is in excess of market demand. . . .

"It is as imperative to avoid waste through premature abandonment as to hold production to market demand which is measured by price just as certainly now as when supply was not regulated."

Andrew F. Schoeppel, chairman of the Kansas Corporation Commission: "This factual, incontrovertible record of prices refutes the charge that proration has increased the public's cost of motor fuel, and the same situation applies to the other petroleum products. . . . The state programs are designed to afford reserves produced at non-wasteful rates that balance supply with demand."

A. Andreas, state geologist of New Mexico and member of the Oil Conservation Commission: "The administration by the Commission of the State's conservation laws has been so satisfactory to its operators that to date there has been no attack in court upon its proration law. The monthly estimate of demand of the Bureau of Mines has been consistently followed in the State's allowable daily production. Within the last two years, the daily allowable has been held under such estimates. It has given fullest coöperation to other states in the Interstate Oil Compact, which has gone far to replace the rivalry between states with constructive coöperation. . . . New Mexico still considers price a paramount issue and if the price is cut it indicates that the market is over-supplied with oil."

Too Much Emphasis on Gas/Oil Ratio

William J. Armstrong, Oil and Gas Conservation Office of the Corporation Commission of Oklahoma: "Considerable emphasis has been put on gas/oil ratio in this proposed bill. It is a highly controversial question and has been for several years because it was one of the first recognized factors in the control of production. . . . In other words, bottom hole pressure is probably the most important factor in the control of reservoir energy as now known, at least from a practical standpoint. This pressure may be either the control of gas energy or hydro-static pressure. In some fields, the gas pressure is almost negligible and the water pressure is the dominant factor and in this case, the control of water movement is of first importance. This principle of control apparently has not been comprehended by the technical proponents of this bill, as indicated by their testimony before this committee and I feel that while gas/oil ratio is important, there has been entirely too much emphasis put on this one factor."

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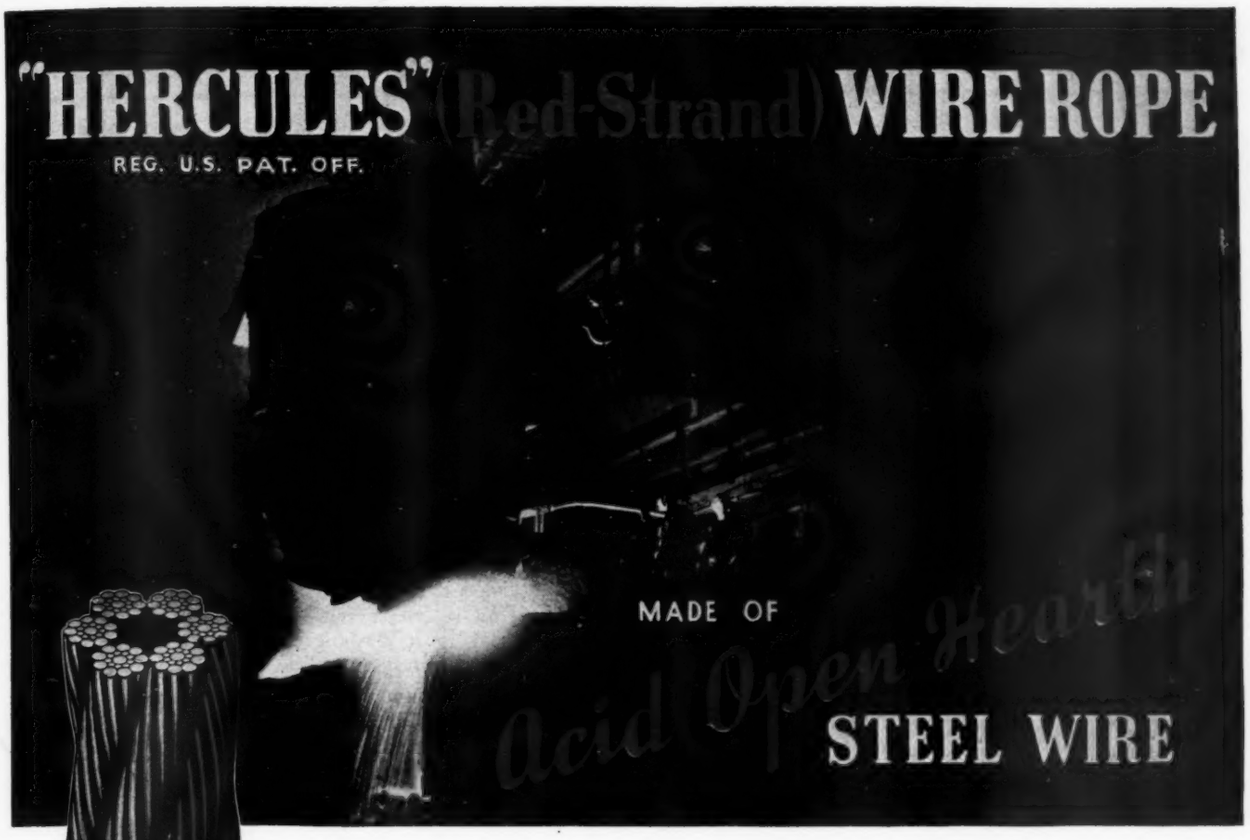

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« « HIGHLIGHTS IN OILDOM » »

Oil Discovered In Netherlands New Guinea

Drilling operations have definitely established the presence of oil in Netherlands New Guinea, according to the Trade Commission in Batavia, and it is believed that the possibilities of commercial production will soon be determined.

The first deep test in the Vogelkop area indicates the presence of oil at a depth of 600 meters. Most of the strata are water-bearing, but the hope exists that at a greater depth purely oil-bearing strata will be found.

The second deep test at Sele has not indicated the presence of oil, the report states, but drilling is continuing. Oil has been discovered at comparatively shallow depths west of Vogelkop. Drilling will begin soon on the Radjo block concession in South Sumatra.

●

Texas Commission Adopts 20-Acre Spacing Rule

In an effort to arrest what is termed excessive drilling, the Texas Railroad Commission adopted a state-wide 20-acre spacing rule, effective February 1.

Under the order a minimum distance of 467 ft. from a property, lease, or subdivision line, and 933 ft. from another well is required for a location. The rule for the state as a whole has been 150 ft. from a property line and 300 ft. from another well, the equivalent of about 2¼ to 2½ acres per well.

Concern over the rapid rate of completion with no immediate prospect of increased demand that would result in adequate allowables has caused the commission for some time to seek a means of curtailing drilling to that actually needed for proper development.

Under the new order, as in the past, the commission may grant permits for wells in exception to the rule if closer spacing is shown necessary to prevent waste or confiscation of property. It may also prescribe special spacing rules for various fields, reducing the spacing requirements if closer drilling is justified.

The order is not retroactive and does not alter special spacing rules already in force in some fields. Many fields have separate rules that require wells to be spaced wider than the specification for the state as a whole. Some rules specify spacing as great as one well to 40 acres.

●

Government May Renew Efforts to Control Submerged Lands

That the Federal Government will renew its efforts to gain control of all submerged lands off the coast of California when congress next convenes, is being looked upon in Washington as a strong possibility. The belief is based in a large measure upon the annual report of the secretary of the navy to congress, in which reference is made to the unsuccessful attempt in 1939 to transfer title to California submerged lands to the Navy Department and its naval petroleum reserves administration, the concluding words of which are: "It is anticipated the department will continue to press for legislation or other action on this important matter when Congress again convenes."

If successful in gaining control of submerged lands off the California coast, it is generally believed an effort will then be made to gain similar control of such lands off Texas, Louisiana, Mississippi, Alabama, Florida, and Georgia.

●

Oil Industry United in Opposition to Cole Bill

United opposition of the petroleum industry to federal control of oil production as embodied in the Cole Bill will be expressed by 18 witnesses who will testify in a coöperative program at the resumed hearings on the bill. The industry statements, prepared through the coöperation of the three largest petroleum associations and of many local oil groups, are expected to be presented before the subcommittee on petroleum (Cole Committee) of the House of Representatives Committee on Interstate and Foreign Commerce beginning about February 19 at Washington, D. C.

Representatives of the American Petroleum Institute, the Independent Petroleum Association of America, the Mid-Continent Oil and Gas Association, and other trade associations, have joined in the preparation of the program, and their testimony will present the petroleum industry's position with respect to the bill.

Resolutions against the bill, which was introduced at the last session of congress, have been adopted by numerous oil-industry groups. They see in it an attempt to impose federal control on the entire industry through a needless duplication of conservation measures that already are enforced by state authorities in almost all leading oil-producing states.

The thesis of proponents of the bill, that the oil and gas industry is operating in a seriously wasteful manner, and is depleting a valuable natural resource without regard for the needs of the future, emphatically is denied by the industry. Testimony to be presented before the committee will deal specifically with these charges.

The statements scheduled for presentation will discuss all phases of the problems of conservation of oil and gas, and will include a detailed analysis of the probable effects of the bill as the oil industry sees it, and a discussion of its constitutionality.

Evidence will be offered to show that the petroleum industry in general is practicing conservation by applying the latest engineering technology to insure maximum recovery of oil from underground reservoirs, that aboveground operations of the industry are conducted with an almost irreducible minimum of avoidable waste, and that prophecies of a rapidly-approaching exhaustion of America's oil reserves are without foundation.

●

Peru Reserves Oil Land For State

Oil lands available for disposal in the Department of Loreto, eastern Peru, are reserved for the State in accordance with existing legislation authorizing such action, according to a resolution adopted by the Peruvian Government and reported by the Trade Commission in Lima. The resolution said that the action is designed to "better promote development of oil lands in the jungle region along the Amazon River."

PENBERTHY

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TRANSPARENT

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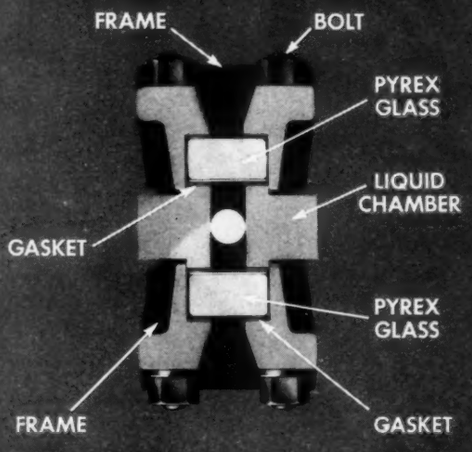

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PENBERTHY PRODUCTS

CANADIAN PLANT:
WINDSOR, ONTARIO

Activities in Refining

Percent Refining Capacity Operated

Western Division, 70.1 Percent **Central Division, 73.6 Percent** **Eastern Division, 83.6 Percent**

MID-CONTINENT Petroleum Corporation has announced through F. B. Koontz, vice-president, that new equipment will be added to its West Tulsa, Oklahoma, plant, involving the expenditure of $2,500,000. The new installations will include a catalytic polymerization unit, catalytic reforming unit, catalytic cracking unit, and a stabilization unit. It is planned to have the new equipment in operation by June 1, Koontz stated.

●

Gulf Plains Corporation, recently organized by Clyde Alexander, Robert T. Wilson, and J. J. Sheerin, has begun construction of a recycling plant midway between the Agua Dulce and Stratton fields, Nueces County, Texas.

The company has assembled a block of 6020 acres, 4400 acres of which were received on assignment from Texon Royalty Company. The acreage assigned by this company covers gas and condensate rights only. Gulf Plains has purchased other leases in the area and placed them under its unitization contract.

The plant will have a capacity of 60,000,000 cu. ft. of gas per day and is expected to be in operation by September 1.

●

Continental Oil Company has announced plans for the construction of a $4,000,000 refinery at Westlake, Louisiana, near Lake Charles. Erection of the plant will begin in April and it will be completed within a year.

The company was granted state tax exemption for a period of ten years in an order signed by Governor Earl K. Long under the provisions of the State Board of Commerce and Industry program devised to attract industry to Louisiana.

●

W. L. Stewart, Jr., vice-president of the Union Oil Company, has announced plans for an extensive building and expansion program for its refinery at Oleum, California.

Stewart stated that at the present time new shops and other facilities for the centralization and modernization of refinery maintenance work are under construction. This building construction is being carried on under contract by the Bechtel, McCone, Parsons Corporation of Los Angeles. Also under construction is the company's new polymerization plant that has been licensed by the Universal Oil Products Corporation. The plant is being built by the Fluor Corporation, and will be completed within the next few months.

In addition to the building program, plans call for the construction of a new coking plant and a hydro-forming unit. The coking plant will process approximately 14,000 bbl. per day of either heavy crude oil or fuel oil.

Incorporating the latest technical developments in the processing of California crude oils, Union Oil Company's hydro-forming unit will produce a high quality gasoline. Construction of the coking and hydro-forming units will begin about June 1 and it is expected the plants will be put into operation in the early part of 1941.

●

The J. M. Huber Corporation, manufacturers of natural gasoline and carbon black, has awarded a contract to Koppers Company, Engineering and Construction Division, Pittsburgh, Pennsylvania, for construction of a Seaboard Process liquid purification plant at Borger, Texas. The plant will be employed to remove hydrogen sulphide from natural gas that is to be used in the manufacture of carbon black.

This will be the largest plant ever built for the purification of natural gas, it is stated. It will have a capacity of 70,000,000 cu. ft. of gas per day.

The purification plant will be situated ahead of the gasoline absorption plant and will be designed to reduce materially the hydrogen sulphide content of both the gasoline and the carbon black. Erection of the plant is expected to begin about March 15. It will be ready to begin operation about May 15.

Crude Runs to Stills, Gasoline, Gas and Fuel Oil Stocks
Week Ended February 3, 1940
A.P.I. Figures
(Figures in thousands of bbl. of 42 gal. each)

DISTRICT	Percent Potential Capacity Reporting	Daily Average Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks	Total Gas and Fuel Oil Stocks
East Coast	100.0	538	87.5	18,715	14,818
Appalachian	87.3	116	80.0	3,893	970
Ind., Ill., Ky.	90.7	487	83.2	14,046	5,553
Okla., Kans., Mo.	81.6	246	71.9	7,944	3,221
Inland Texas	50.3	96	60.4	1,815	1,923
Texas Gulf	90.0	840	88.4	14,328	8,888
La. Gulf	97.8	118	67.4	3,103	1,539
No. La. and Ark.	55.0	44	80.0	645	671
Rocky Mt.	54.2	47	73.4	1,477	621
California	90.0	498	66.8	17,151	88,453
Reported	86.4	3,030	79.0	83,117	126,657
Estimated Unreported	.....	365	.....	6,220	2,740
*EST'D TOTAL U. S. FEB. 3, 1940	.....	3,395	.....	89,337	129,397
*EST'D TOTAL U. S. JAN. 27, 1940	.....	3,470	.....	87,914	130,422
U. S. B. OF M. *FEB. 3, 1939	.....	**3,134	.....	80,089	147,644

*Estimated Bureau of Mines' basis.
**January-February, 1939, daily average.

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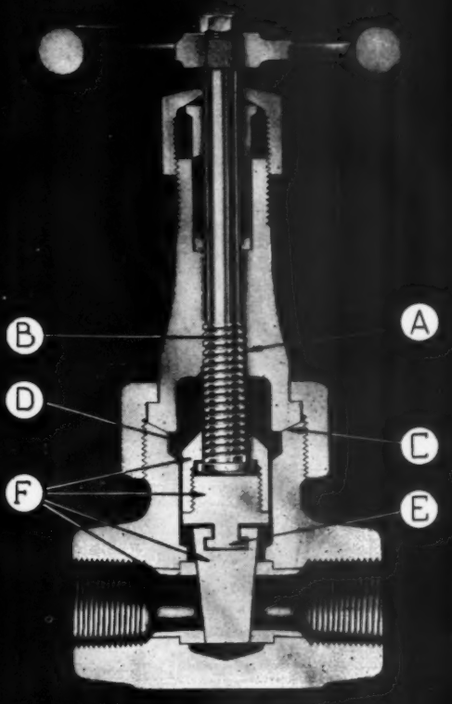
FOR ALL SMALL VALVE WORK

These Chapman List 960 Valves are compact, forged steel, gate valves which have put a stop to the constant repairs and replacements usually necessary in the case of small bronze or iron valves. For all small valve work, List 960 offers years of trouble-free service on a wide range of pressures—to 800 lbs at 750 degrees, or 1500 lbs. cold working pressure. They are available in all sizes from ¼" to 2", with screw ends for threaded pipe.

This tough, all-purpose valve is now made in two types, the *outside screw* and the *inside screw*, both with rising stem. Body, Bonnet and Union Nuts are forged steel. Stem, Wedge and Seat Rings are stainless steel, made to exact gage and absolutely interchangeable. For real economy, they challenge comparison with valves of any other type or material.

Outside Screw Model
Chapman List 960
Steel Gate Valve



Sectional View
Inside Screw Model
List 960 Steel Gate Valve

A—All Threads Inside the Valve
B—Quick Acting Threads
C—Ball Joint Connection
D—Full Pressure Repacking
E—Flexible Stem Connection
F—Replaceable Stainless Steel Parts

THE CHAPMAN VALVE MANUFACTURING COMPANY

INDIAN ORCHARD, MASS.

Activities in the Oil Fields

SHELL Oil Company has opened a new deep oil pool in East Texas with its Campbell No. 1, in the Chapel Hill area, 12 miles east of Tyler. The well initially produced 15 bbl. of oil an hour through 4/16-in. to 7/16-in. chokes after swabbing. Production is from the Pettit zone at a depth of 8058-68 ft. The well is two miles northeast of the Hunt discovery well in the Chapel Hill area, which made only gas and distillate.

●

Crown Central Petroleum Corporation Ernsting No. 1, in CWL NE SE of 1-20-12w, opens the first pool of 1940 for Barton County, Kansas, and is the third discovery of the year for the state.

The well, which is three-fourths of a mile southeast of the Wolf pool, qualified for a state potential of 191 bbl. per day after treatment with acid. Production is from the Arbuckle lime at a total depth of 3375 ft.

●

J. W. Carter et al Johnson No. 1, SW NW NE of 25-6s-8e, which found saturation from 2507-28 ft. and which is rated as good for 700 bbl. per day, opens a new pool in White County, Illinois. The oil tests 38 gravity or better and has no salt content. It is also said to be the sweetest crude oil produced in the state.

The discovery is southeast of the Storms pool, which is producing from a different zone. Oil from the Storms pool contains a rather high salt content. Johnson No. 1 is said to be producing from the Hardinsburg zone.

●

After obtaining a showing of oil in the Viola lime, the Pawnee Royalty Company has decided to go deeper with its Meyer No. 1 near Falls City, Nebraska, believing either the Wilcox or Arbuckle may prove more productive. The oil showing was found in the first 10 ft. of the Viola formation.

●

Manhattan Fruit Company No. 1 of the Tide Water Associated Oil Company, in 35-21s-30e, Venice field, Plaquemines Parish, Louisiana, has been completed producing 147 bbl. of 31.7 gravity oil in 16 hours through a 1/8-in. choke. Production is from a depth of 7670-7706 ft. The completion opens the seventh producing zone in the Venice area.

●

D. M. Day No. 1 of A. J. Holifield has opened a new producing area in the Balcones Fault Zone, two miles southwest of Luling, Guadalupe County, Texas. The well headed oil after being acidized. The heads were at the rate of 15 bbl. per hour. The oil tested 37 gravity.

Production is from the basal Taylor, Austin chalk, and Buda limestone. Casing is set at a depth of 2337 ft., 44 ft. above the base of the Taylor. The Austin chalk was entered at a depth of 2381 ft. The hole was drilled to 2830 ft., 18 ft. into the Edwards lime, but water was encountered, and the test was plugged-back to 2685 ft., base of the Buda lime.

Structurally the well is on the fault series that controls the Salt Flats field and the Manford area and is located between the two pools.

●

Paul McIntyre et al McMahan No. 1, NW NW SE of 36-11-9, an extension of the Okemah pool, Okfuskee County, Oklahoma, swabbed and flowed 70 bbl. of oil in two hours, reviving interest in the area. The test had filled 1000 ft. with oil in 2½ hours, was shut in, and filled to 3500 ft. The first Wilcox was found at a depth of 3764 ft. and the second Wilcox at 3788 ft.

AVERAGE CRUDE OIL PRICES

California		**Louisiana**	
Kettleman Hills	$1.12-1.38	Rodessa	$1.05
Playa Del Rey	.65-1.08	Gulf Coast	.79-1.28
Coalinga	.60- .82	North Louisiana	.73-1.05
Wilmington	.64-1.14	Illinois	.95-1.05
Montana	.90-1.10	Kentucky	.90-1.10
Wyoming	.35-1.30	Indiana	.95
Colorado	.90- .98	Ohio	
New Mexico	.53- .95	Lima	.90
Texas		Michigan	.74-.97½
North Central	.71-1.03	Pennsylvania	
Panhandle	.67- .96	Bradford	2.75
West Texas	.53- .95	Southwest	2.40
Gulf Coast	.86-1.28	Eureka	2.34
Darst Creek	.96	Buckeye	2.30
East Texas	1.10	Corning	1.12
Talco	.65	Canada	2.10-2.17
Kansas	.60-1.10		
Oklahoma	.60-1.10		
Arkansas	.73-1.05		

DAILY AVERAGE CRUDE OIL PRODUCTION

Data Supplied by A.P.I.

(Figures in bbl. of 42 gal. each)

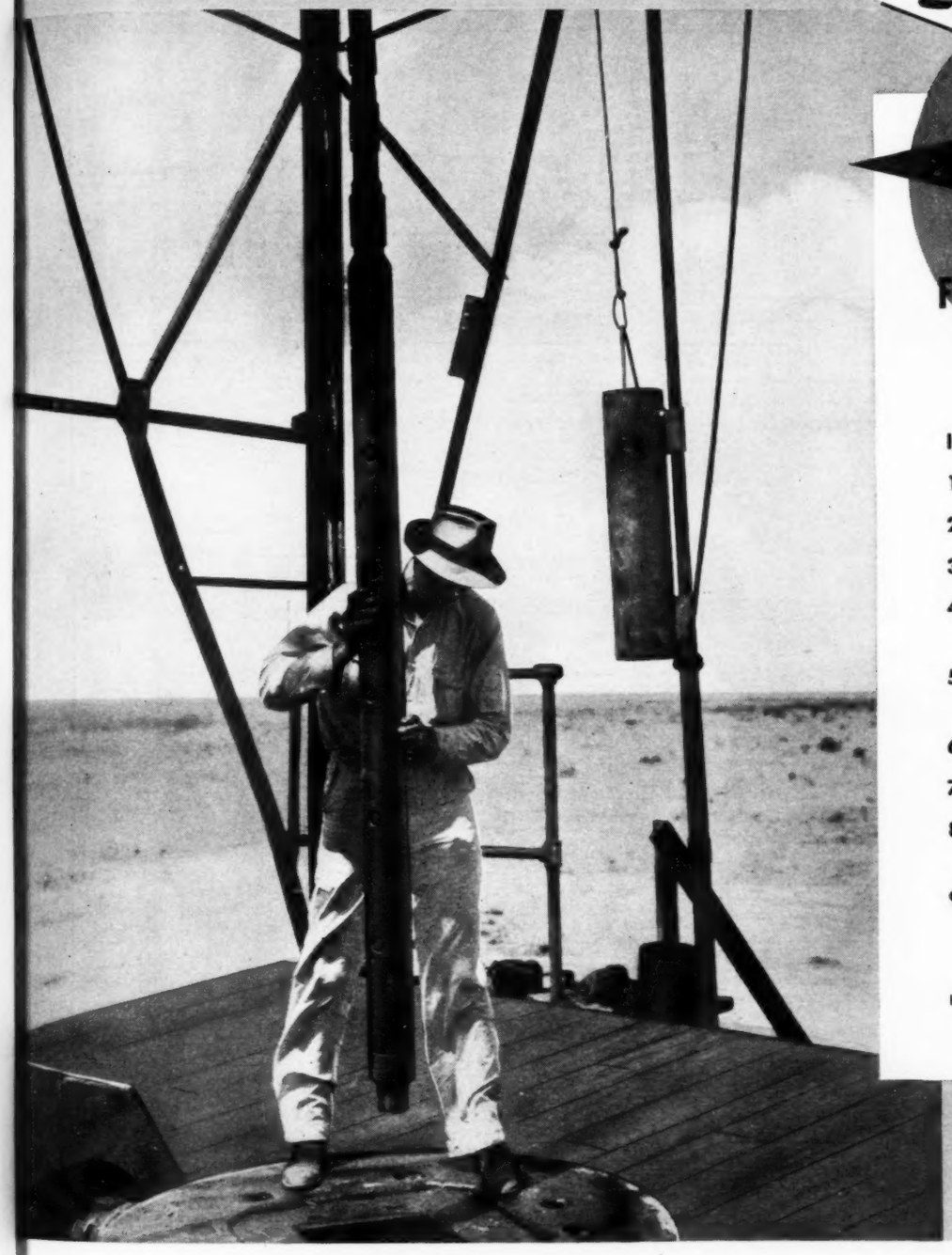
	[1]B. of M. Calculated Requirements (January)	Week Ended Feb. 3, 1940	Week Ended Dec. 30, 1939	Week Ended Feb. 4, 1939
Oklahoma	433,900	[2]405,650	[3]418,200	422,000
Kansas	160,600	[2]181,600	[3]178,600	140,150
Nebraska	.....	[2] 100	.....	.....
Panhandle Texas	.....	70,000	73,600	65,900
North Texas	.....	84,000	76,350	87,700
West Central Texas	.....	33,000	26,850	31,850
West Texas	.....	195,850	227,150	239,800
East Central Texas	.....	66,950	81,600	101,700
East Texas	.....	394,600	394,400	447,150
Southwest Texas	.....	193,600	202,550	280,700
Coastal Texas	.....	204,300	223,400	241,150
TOTAL TEXAS	1,411,000	1,242,300	1,305,900	1,495,950
North Louisiana	.....	68,350	68,200	69,400
Coastal Louisiana	.....	203,250	198,850	191,650
TOTAL LA.	254,200	271,600	267,050	261,050
Arkansas	59,700	70,650	70,650	52,350
Mississippi	.....	[2] 4,600	[3] 1,700	.....
Illinois	314,800	372,950	337,850	146,700
Indiana	3,900	[2] 6,600	.....	94,650
Eastern (Not incl. Ill. and Ind.)	96,800	94,850	103,600	
Michigan	61,000	63,250	67,300	51,650
Wyoming	58,700	61,550	62,750	48,400
Montana	15,400	17,050	17,050	12,800
Colorado	3,900	4,800	4,200	4,000
New Mexico	101,900	101,050	109,050	101,950
TOTAL EAST OF CALIF.	2,975,800	2,898,600	2,943,900	2,831,650
California	593,900	600,200	601,100	610,300
TOTAL U. S.	3,569,700	3,498,800	3,545,000	3,441,950

[1]These are U. S. Bureau of Mines' calculations of the requirements of domestic crude oil based upon certain premises outlined in its detailed forecast for the month of January. As requirements may be supplied either from stocks, or from new production, contemplated withdrawals from crude oil inventories must be deducted from the Bureau's estimated requirements to determine the amount of new crude to be produced.

[2]Oklahoma, Kansas, Nebraska, Mississippi, and Indiana figures are for week ended 7 a. m., January 31.

[3]Oklahoma, Kansas, Mississippi, and Nebraska figures are for week ended 7 a. m., December 27.

Boost Production!



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3. Removing cement sheaths.
4. Cleaning out cavings from wells.
5. Removing paraffin from face of pay.
6. Removing mud sheaths.
7. Drilling out cement plugs.
8. Deepening wells bottomed in limestone.
9. Cleaning gyp from face of pay, screens and liners.

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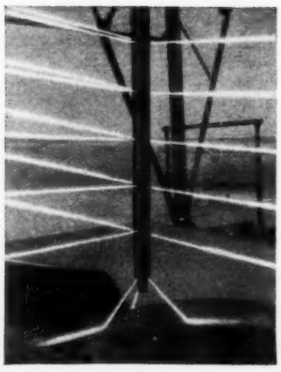
Dowell engineer explaining mechanism of the gun to a field man. Attention is called to the jets through which the acid is impinged against the walls or bottom of the well bore.



The Jet Gun is designed to be connected to the lower end of the tubing. Thus it can be raised, lowered or rotated during the treating process. Here the gun is being tested, after assembly, prior to actual treatment.

THE MANY BENEFITS the Acid Jet Gun brings to oil producers are the result of an intensive program of cooperation and research.

This program embraces three sources—the oil producer, Dowell Incorporated and The Dow Chemical Company, Dowell's parent organization. Not only is this triple alliance responsible for the Acid Jet Gun but for many other developments of extreme importance in the field of chemical service for oil and gas wells. The Dow Chemical Company provides Dowell with a technical background that is a very decided advantage to oil producers everywhere. And oil producers, recognizing the great importance of this combination, are looking to Dowell in ever-increasing numbers.

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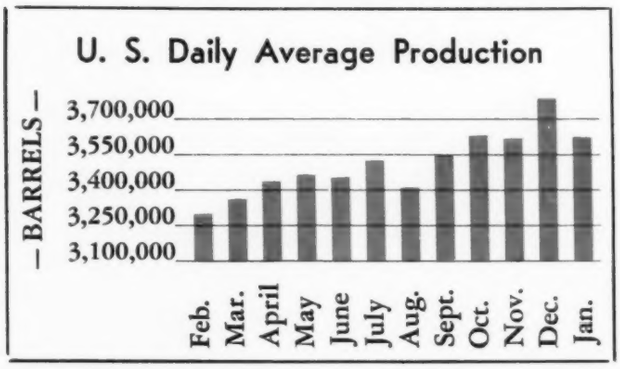
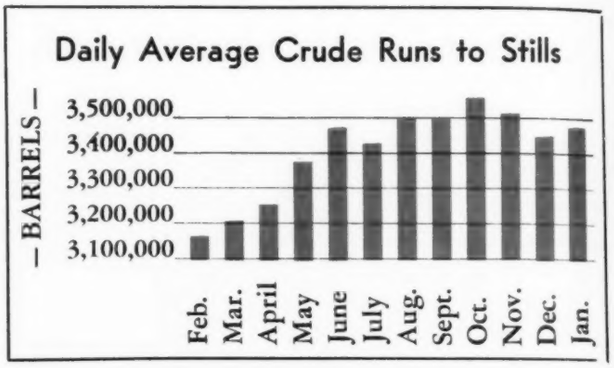
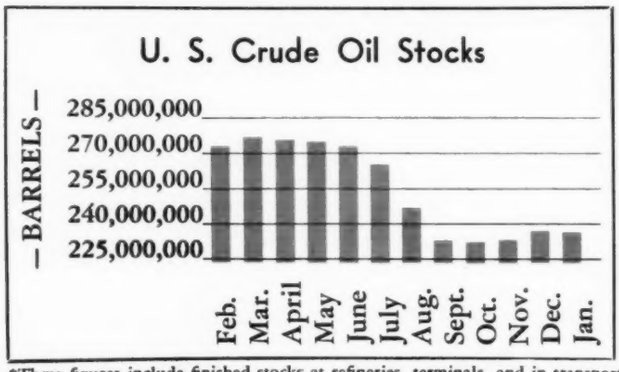
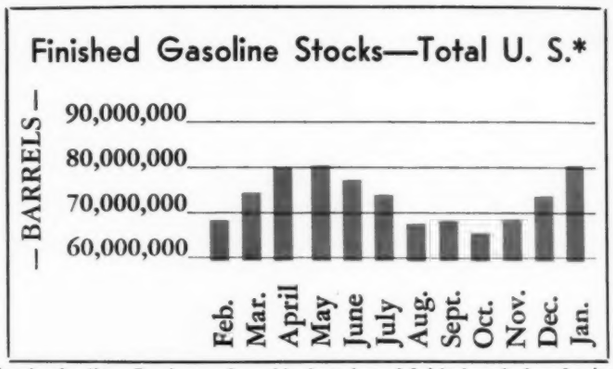
Petroleum Statistics and Field Activities









*These figures include finished stocks at refineries, terminals, and in transportation in pipe lines. Previous to June this chart showed finished stocks in refineries only. Above statistics by the American Petroleum Institute.

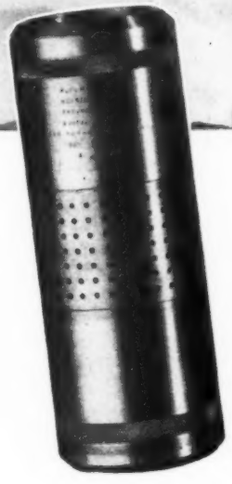
Summarized Operations in Active Fields for January, 1940

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
Texas								
East Texas	27	23	8	13	3500-3700	2	40	Rotary
Duval County	35	22	3	12	1554-2900	2	22	Rotary
Ector County	51	50	24	66	3675-4377	2 and 3	32-36	Rot.-Cab.
Panhandle	50	50	15	59	1700-3900	2	40	Rotary
Refugio County	8	8	2	4	4900-5900	2	38	Rotary
Nueces County	15	10	4	13	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	30	30	26	37	3730-3935	2	42-43	Rot.-Cab
Oklahoma								
Fitts Pool	13	6	2	7	1800-4488	2 or 3	38	Rotary
Kansas								
Russell County	19	18	6	27	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	25	21	4	22	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	16	13	7	20	3290-3518	2	39-42	Rot.-Cab.
Illinois								
Central Illinois	234	184	321	68	1425-4100	2	36-38	Rot.-Cab.
New Mexico								
Lea County	30	29	10	47	3150-4030	3	30-34	Rot.-Cab.
California								
Kettleman Hills	10	10	8	16	8300-8730	3 or 4	40	Rotary
Wilmington	23	23	15	14	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for January, 1940

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1939 (In Barrels)
	January	December	January	December	January	December	January	December	January	December	
Arkansas	14	17	12	12	8	15	4	5	39	45	21,266,994
California	118	111	104	101	117	81	105	85	190	206	224,336,682
Colorado	2	0	1	0	....	....	1	1	25	32	1,402,599
Illinois	234	343	184	284	446	479	321†	358**	86	80	92,915,620
Indiana	32	50	21	32	....	....	5	8	71	70	1,426,000
Kansas	121	147	101	117	140	194	46	48	275	273	59,952,340
Kentucky	22	68	12	33	....	....	11	10	91	101	5,611,500
Louisiana	123	156	100	114	122	151	32	35	187	185	94,110,736
Michigan	112	140	76	87	160	121	50	39	181	173	23,185,203
Mississippi	14	9	9	4	....	....	3	5	23	22	102,918
Montana	19	16	14	14	....	....	3	3	40	43	5,901,058
New Mexico	74	65	59	53	81	64	26	24	146	142	37,453,117
New York	94*	102*	94*	102*	....	....	15	13	44	46	5,105,000
Ohio	105*	104	78*	76	....	....	45	38	182	185	3,157,500
Oklahoma	153	216	91	124	189	216	56	45	323	315	156,421,939
Pennsylvania	193*	162*	173*	160*	....	....	....	....	....	....	17,342,500
Tennessee	0	0	0	0	....	....	....	....	....	....	....
Texas	830	901	643	687	1148	1122	493	420	1598	1382	485,847,999
West Virginia	72	75	57	63	....	....	20	23	142	150	3,556,500
Wyoming	20	14	17	10	....	....	3	4	60	65	21,408,478
Total	2352	2696	1846	2073	2411	2443	1239	1164	3703	3515	1,260,504,683

*Includes water-intake and pressure wells.
**Includes 276 rigs standing and 28 rigging-up.
†Includes 253 standing and 68 rigging-up.



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Major Pipe Line Activities

DIRECTORS of Inland Empire Refineries, Inc., are expected to decide sometime this month whether a crude oil pipe line will be laid from the Cut Bank field, Montana, to Spokane, Washington, a distance of 320 miles. An announcement by Henry D. Moyle, vice-president of the company, indicates that initial surveys of the line have established its practicability from an engineering standpoint. A major consideration will be the action of the Interstate Commerce Commission regarding freight rates on crude oil from Montana fields to the Spokane area. Producers and refiners assert that at present rail rates are so prohibitive that consumers can ship crude oil into the area from California via ocean barge and the Columbia River at less cost than they can ship by rail from Montana. Laying of the line would make it possible for Montana operators to compete in this market with California producers.

If laid the line will consist of 313 miles of 6-in. and 7 miles of 4-in. pipe. Two pumping stations would be constructed. The maximum capacity of the line would be 6000 bbl. per day. Present capacity of the refineries at Spokane totals 3500 bbl., and should the line be laid it is expected that this volume would be increased. A part of the line's deliveries might also be sent to the Inland Empire refinery at Pocatello, Idaho, as well as to the Yale Oil Corporation's plant at Kalispell, Montana. The latter has a capacity of 1500 bbl. per day.

Laying of the line is expected to result in accelerated development of Montana fields inasmuch as the excess production now available in the area is considerably less than the 6000 bbl. per day that would be required to operate the line at capacity. Approximately 2000 bbl. of crude oil per day are not subject to current commitments, it is estimated, which would necessitate considerable new drilling.

●

Sohio Pipe Line Company, subsidiary of the Standard Oil Company of Ohio, has awarded contracts to Sheehan Pipe Line Construction Company and Truman-Smith Construction Company to lay 250 miles of 12-in. oil pipe line from Stoy, Illinois, to Lima, Ohio.

From Stoy to Hagerstown, Indiana, the line will parallel the Tide Water Pipe Line Company line acquired by Sohio in July, 1939. From Hagerstown this line will run northeastward to Lima.

Sheehan Pipe Line Construction Company will lay the line from Stoy to Paragon, Indiana, and from a point on the Ohio line to Lima. From that point to Paragon the line will be laid by Truman-Smith Construction Company.

The line is expected to be completed about April 1. Its capacity will be approximately 60,000 bbl. per day.

●

Tentative approval has been given the Kansas Pipe Line and Gas Company by officials of the Reconstruction Finance Corporation for the laying of a 1000-mile pipe line from the Panhandle of Texas to the iron ore fields of Minnesota. The announcement was made after Colonel Ernest O. Thompson, of the Texas Railroad Commission, had appeared before the R.F.C. to assure that body that the additional outlet for natural gas from the Panhandle area was desirable, that ample gas reserves are available, and that those behind the project have sound financial backing. Approval of the project already has been given by the Federal Power Commission, and final approval of financing, including a loan of $11,500,000 from the R.F.C., is said to await only the completion of minor details.

The line would have a capacity of 120,000,000 cu. ft. of gas per day and would serve, in addition to the iron works, 120 cities and towns having an aggregate population of 500,000.

A breakdown of the $33,000,000 project shows that $9,000,000 would be spent for line pipe for the trunk line, $2,000,000 for freight and other transportation costs, $3,000,000 for gate valves and other appurtenances, $6,000,000 for labor, $11,000,000 for auxiliary distribution systems, and $1,000,000 for gathering lines, leaving $1,000,000 for rights-of-way, engineering, overhead, and miscellaneous expenses.

●

H. C. Price Company, Bartlesville, Oklahoma, announces that it has been awarded the contracts for electric welding and has started construction on the following pipe lines:

For Sohio Pipe Line Company, 250 miles of 12-in. from Stoy, Illinois, to Lima, Ohio. The general contractors are Sheehan Pipe Line Construction Company and Truman-Smith Construction Company.

For Panhandle Eastern Pipe Line Company, 140 miles of 22-in. and 24-in. loops in Kansas, Missouri, and Illinois. The general contractors are T. R. Jones, Inc., and I. C. Little.

For Shell Oil Company, Inc., 10 miles of 6-in. and 8-in. in Illinois. The general contractor is I. C. Little.

All lines are to be electric welded using the Fleetweld process.

●

Sinclair Refining Company, Pipe Line Department, has awarded the contract for construction of 66 miles of 8-in. crude oil pipe line to O. C. Whitaker Construction Company, Fort Worth, Texas. The line will loop an existing 6-in. line from the K.M.A. field, Wichita County, to the company's Hensley station in Jack County, Texas. The line is expected to be completed the early part of March.

●

H. L. Gentry Engineering Company is constructing for the Dow Chemical Company, Midland, Michigan, a 60-mile, 6-in. gas pipe line from the company's Midland plant to the Temple oil field. The chemical company has contracted for purchase of gas from the O. H. Grimes casinghead gasoline plant now under construction in the Temple field and scheduled to begin operating March 1.

●

The Texas Pipe Line Company has announced it will lay 23 miles of 8-in. welded oil pipe line from the Bay City field, Texas, to connect at West Columbia with the company's trunk line.

P 213.3
P 621.

THE Petroleum Engineer

FEBRUARY, 1940

The Compressibility of Gases

II. Gaseous Mixtures

By
GEORGE GRANGER BROWN
Professor of Chemical Engineering
University of Michigan
and
DYSART E. HOLCOMB
Assistant, Department of Chemical Engineering
University of Michigan

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

IN ACTUAL operation an engineer is frequently required to compute the pressure exerted by a known quantity of a gaseous mixture at a specified temperature. At low pressures and at temperatures somewhat higher than the condensing temperature, the gaseous mixture may be treated as a mixture of ideal gases, or as a single ideal gas having a molecular weight equal to the average molecular weight of the mixture.

But where accurate results are desired, and for all calculations at high pressure, it is necessary to give due consideration to the deviations from the ideal gas relationship. The different methods of treating these deviations for pure gases are also used in calculations dealing with gaseous mixtures.

Ideal Gases

According to the ideal gas relationship and Dalton's law of partial pressures, the *partial pressure* of a single component of a gaseous mixture is the pressure that would be exerted by that

GEO. GRANGER BROWN

graduated with a bachelor's degree in chemical engineering from New York University in 1917—Served with the Aluminum Company of America at Massena, New York, with the Chemical Warfare Service at Washington, D.C., then as production manager for the Union Special Machine Company in Chicago, and Youngstown Sheet and Tube Company at Evanston, Illinois—In 1920 joined the staff of the Department of Chemical Engineering, University of Michigan—Post-graduate studies led to the doctor's degree received in 1924—The professional degree of chemical engineer was granted by New York University in 1925—Was awarded the William H. Walker Award for 1939 for meritorious contributions to chemical engineering literature.

DYSART E. HOLCOMB

received B.S. degree in chemical engineering from Texas Technological College in June, 1937, and M.S. degree in chemical engineering from the University of Michigan in June, 1938—Is candidate for degree of Ph.D. in chemical engineering at present time—During summer following completion of M.S. degree worked with technical service division, Humble Oil and Refining Company, Baytown, Texas—Is now working with Dr. Brown and Dr. D. L. Katz on correlation of physical and thermal properties of the pure paraffin hydrocarbons and paraffin hydrocarbon mixtures—Last two years has acted as assistant to Dr. Brown in chemical engineering department, University of Michigan.

single component if it alone were present in the same total volume and at the same temperature as the mixture; and the total pressure exerted by a gaseous mixture is equal to the sum of the partial pressures of the individual components.

Similarly the *partial volume* of a single gaseous component in a mixture of ideal gases is the volume that would be occupied by that single component if it alone were present at the same pressure and temperature as the mixture. Amagat's law (also called Leduce's law) states that the total volume occupied by a gaseous mixture is equal to the sum of the partial volumes so determined.

Both of these laws are applicable together only to ideal gases. But for actual gases Dalton's, or Amagat's law, may be applied separately with much greater accuracy than the law of ideal gases. Which of these laws gives the better approximation depends upon the conditions and the nature of the gaseous mixture. In some cases, such as mixtures of argon and ethylene, Dalton's law of additive pressures is more nearly accurate; for other mixtures such as nitrogen and hydrogen, Amagat's law of additive volumes gives more satisfactory results.

When applying Dalton's law of additive pressures, Van der Waal's equation may be used by applying it to each of the individual components. The pressure of the entire mixture may then be obtained as the sum of the partial pressures. The application of Amagat's law of additive volumes is complicated when used with Van der Waal's equation. For this reason the use of a mean compressibility factor, Z_m, is frequently used when determining the properties of a gaseous mixture in connection with Amagat's law of additive volume.

The Mean Compressibility Factor

Equation 4[1] may be rewritten as follows for a gaseous mixture:

$$PV = Z_m\, NRT \quad . \quad . \quad . \quad . \quad (8)$$

If Amagat's law of additive volume applies:

$$Z_m = \frac{Z_a n_a + Z_b n_b + Z_c n_c + \cdots}{N} \quad . \quad . \quad (9)$$

in which

Z_a = the compressibility factor of component, a, at the temperature and total pressure of the mixture as determined for the single component, a, in the manner described using Fig. 1[1].

Results obtained by this procedure are satisfactory only when Amagat's law of additive volume applies to the mixture with satisfactory results. The results are reasonably satisfactory when applied to hydrocarbon gases except that large errors appear when the conditions of the mixture are close to the critical points of some of the important components.

[1]See "Part I, Pure Gases" of "The Compressibility of Gases" by George Granger Brown, *The Petroleum Engineer*, January, 1940.

Ideal Solutions

Mixtures following Amagat's law of additive volumes are called ideal solutions. The concept of an ideal solution is of much more general application than the concept of an ideal gas. We find many solutions that are approximately ideal, but which are by no means ideal gases. In fact the concept of an ideal solution was originally applied to liquid solutions rather than to gaseous solutions and it is perfectly obvious that the law of ideal gases will not apply to a liquid solution.

The Residual Volume

As in Equation 3[1], which defines the residual volume of a single gaseous component as the difference obtained by subtracting the actual volume of the gas from the volume computed by the ideal gas laws, we may define a residual partial volume to be used as an additive correction in determining the volume of a solution. The residual partial volume, $\overline{(V)}$, may be defined as the difference obtained by subtracting the actual partial volume of one lb.-mole of the gas from the volume of one lb.-mole as computed by the ideal gas laws for the same temperature and total pressure of the mixture.

$$\overline{(V)} = \frac{RT}{P} - \overline{V} \quad . \quad . \quad . \quad (10)$$

in which equation, $\overline{V}$ is the actual volume of one lb.-mole of the single component when present in a solution at a definite temperature, pressure, and composition. The residual partial molal volume, $\overline{(V)}$, includes not only the correction to be subtracted from the ideal gas volume to obtain the actual volume of the gaseous component, but also the correction to be subtracted from the volume of the pure gaseous component to obtain the volume of that component when it is present in a gaseous mixture. The residual partial volume, therefore, is a function not only of temperature and pressure but also of composition, and can be accurately determined only from complete experimental data.

TABLE 2

Computation of Molecular Weight of a Natural Gas, A.

	Component	*Percent by gaseous volume, or molecular percent*	*Molecular weight of component**	*Sum of the products is the average molecular weight*
Methane	CH_4	83.19	16.04	13.34
Ethane	C_2H_6	8.48	30.07	2.55
Propane	C_3H_8	4.37	44.09	1.93
*Iso*butane	i-C_4H_{10}	0.76	58.12	0.44
*n*Butane	n-C_4H_{10}	1.68	58.12	0.98
*Iso*pentane	i-C_5H_{12}	0.57	72.15	0.41
*n*Pentane	n-C_5H_{12}	0.32	72.15	0.23
Hexanes	C_6H_{14}	0.63	86.17	0.54
				20.42

*From Table 1.

TABLE 3

Computation of Pseudo-Critical Temperature and Pressure of Natural Gas, A.

1 *Component*	2 *Mole fraction*	3 *Individual absolute critical temperature* T_c, °R	4 (2 x 3) *Absolute pseudo-critical temperature*	5 *Individual absolute critical pressure,* P_c, *lb. per sq. in.*	6 (2 x 5) *Absolute pseudo-critical pressure*
CH_4	0.8319	344	286.	673	560.
C_2H_6	0.0848	549	46.6	712	60.4
C_3H_8	0.0437	666	29.1	617	27.0
i-C_4H_{10}	0.0076	732	5.56	544	4.13
n-C_4H_{10}	0.0168	766	12.9	551	9.26
i-C_5H_{12}	0.0057	829	4.73	483	2.75
n-C_5H_{12}	0.0032	846	2.71	485	1.55
C_6H_{14}	0.0063	914	5.76	435	2.74
			393.4		667.8

Sage and Lacey[2] have outlined a fairly satisfactory method of estimating these residual partial volumes for methane, ethane, propane, and butane in gaseous mixtures based on tabulated experimental data on binary systems. The results obtained are sufficiently accurate for engineering computations, but the computations are somewhat tedious, particularly when it is desired to compute the pressure when volume and temperature are known for a given quantity of gas.

The Compressibility Factor

All the conveniences of the compressibility factor in the case of single component gases, could be extended to gaseous mixtures if we could determine an apparent or pseudo-critical temperature and pseudo-critical pressure for the gaseous mixture that might be used in the same manner as the critical temperature and critical pressure for the single component gas.

Fortunately this procedure can be followed with very satisfactory results if the molecular average critical temperature for the mixture is used as the pseudo-critical temperature, and the molecular average critical pressure of the mixture is used as the pseudo-critical pressure. Once the pseudo-critical temperature, and pressure, are computed for a given mixture, these values remain constant for all temperatures and pressures, and the values of Z to be used in equation 4 may be obtained from Fig. 1 in exactly the same manner for a pound molecular weight of the gaseous mixture as has been described for a pound molecular weight of a pure compound.

Sample Computation

The application of the pseudo-critical temperature, and pressure, in the determination of the compressibility factor, Z, for a gaseous mixture such as a natural gas is outlined in the following illustration. Using natural gas A, as reported by Sage and Lacey, as an example, the average molecular weight of the gas may be calculated as in Table 2.

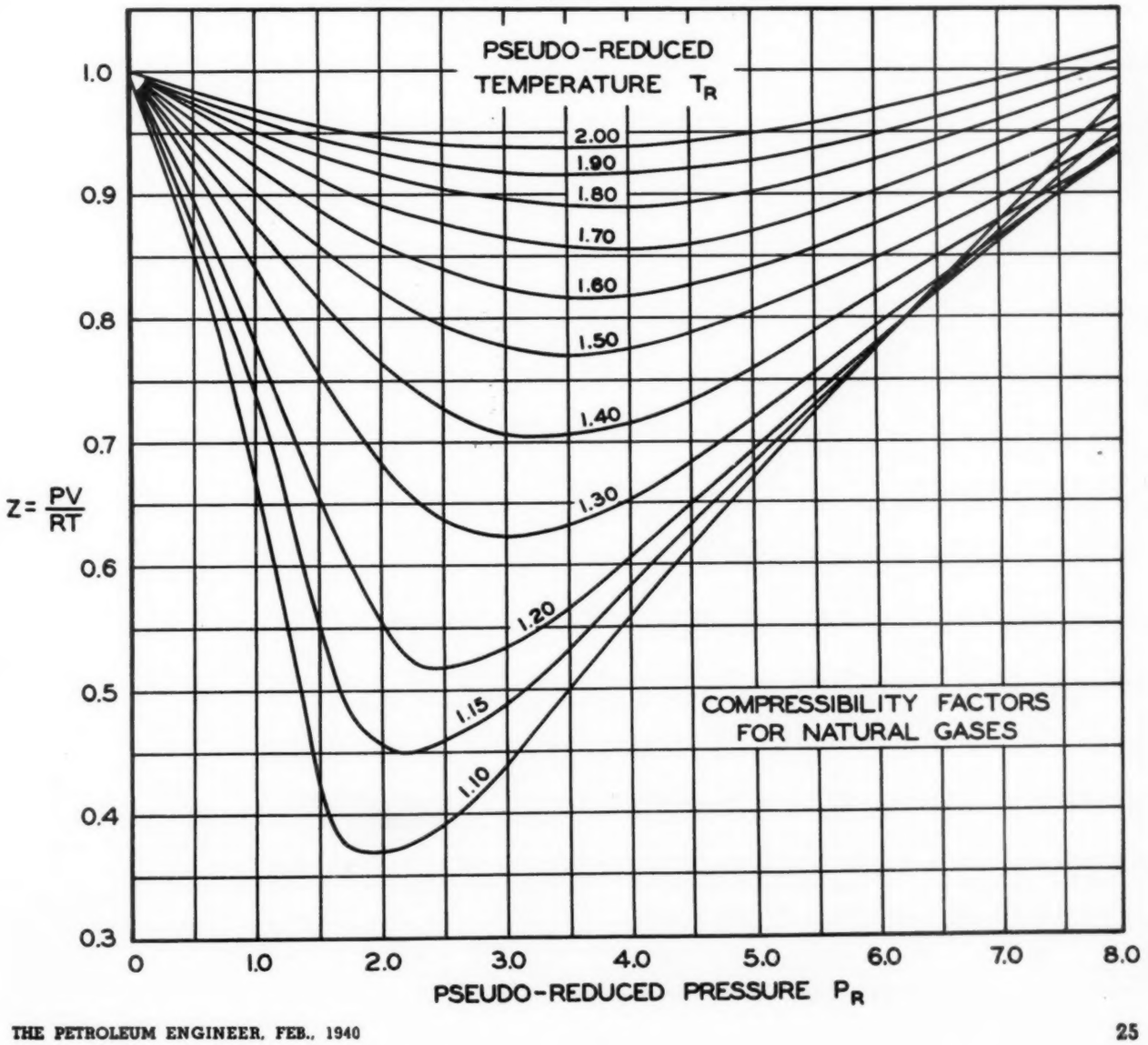
The average molecular weight of a gaseous mixture computed in this manner is the molecular weight of the gas to be used when applying the ideal gas equation or the compressibility factor to the computations involving that gas.

The *specific gravity* of the gas referred to air is computed by dividing the molecular weight of the gas by the molecular weight of air or in this case

$$\frac{20.42}{28.9} = 0.707$$

[2] "Partial Volumetric Behavior of the Lighter Paraffin Hydrocarbons in the Gas Phase" by B. H. Sage and W. N. Lacey. Paper presented November 17, 1939, at Twentieth Annual Meeting, A.P.I., Chicago, Illinois.

Fig. 4. Compressibility factors for natural gases



In a similar manner using the absolute critical temperatures and pressures for the individual components as given in Table 1[1], the pseudo-critical temperature, and pressure, for natural gas A may be computed as in Table 3.

The pseudo-critical temperature of natural gas A is 393.4°F. above the absolute zero. The pseudo-critical pressure for natural gas A is 667.8 lb. per sq. in. absolute. These two values are constant for all computations involving the pressure-temperature-volume relationships of natural gas A.

From the pseudo-critical temperature and the pseudo-critical pressure, the pseudo-reduced temperature, T_r, and the pseudo-reduced pressure, P_r, may be computed for any temperature and pressure condition, by dividing the absolute temperature by the pseudo-critical temperature, and dividing the absolute pressure by the pseudo-critical pressure.

For example, if we wish to compute the compressibility factor, Z, for natural gas A at a temperature of 100°F. and 2000 lb. per sq. in. absolute, the pseudo-reduced temperature is

$$\frac{460 + 100}{393.4} = 1.423 = T_r$$

Similarly, the pseudo-reduced pressure for these conditions is

$$\frac{2000}{667.8} = 2.995 = P_r$$

Using these pseudo-reduced temperatures and pressures for the purpose of determining the compressibility factor, Z, in connection with Fig. 1, which correctly indicates the compressibility factor for pure methane, a value of $Z = 0.740$ is obtained.

Accuracy of Fig. 1 Applied to Natural Gases

It has been found that the volume of a natural gas computed in this manner using values for Z obtained from Fig. 1, is usually from 1 to 3 percent too high. It is to be expected that natural gases, which are not pure methane, or other mixtures containing methane, would not follow exactly the reduced equation for pure methane. As an approximate correction to apply when used for natural gases, the values of Z obtained from Fig. 1 should be reduced by subtracting 0.01 if the absolute pressure is approximately 1000 lb. and 0.02 if the pressure is approximately 2000 lb., and 0.03 if the pressure is about 3000 lb. Fig. 1 should be used without correction whenever the natural gas is substantially pure methane, or when the gas contains an amount of nitrogen or air approximately equal to the ethane, propane, and other heavier hydrocarbons. Complete data are not available on such mixtures, but this practice is recommended for the present.

Compressibility Factor for Natural Gases

Based on the best data available as to the volume of natural gases, and binary mixtures containing methane, Fig. 4 has been prepared giving the compressibility factor, Z, as a function of pseudo-reduced temperature and pseudo-reduced pressure. This plot is entirely satisfactory for all engineering computations involving natural gases that are predominantly methane, and for binary mixtures containing methane.

Using Fig. 4, which is especially prepared for natural gases, the value of Z for natural gas A at 100°F. and 2000 lb. per sq. in. absolute, or a pseudo-reduced temperature of 1.423 and a pseudo-reduced pressure of 2.994, is 0.724.

Using this value for Z in equation 4

$$PV = ZNRT \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and the molecular weight of 20.42 for natural gas A, the volume of one lb. of this gas at the indicated temperature and pressure is found to be 0.1064 cu. ft. as indicated below

$$V = \frac{ZNRT}{P}$$

$$V = \frac{0.724 \times 0.0490 \times 10.71 \times 560}{2000}$$

$$= 0.1064 \text{ cu. ft.}$$

A comparison of the results obtained by the use of Fig. 4 and the pseudo-reduced temperatures and pressures, with the results obtained using the partial residual volume as explained by Sage and Lacey is given in Table 4.

From the comparison of Table 4 it appears that the use of the compressibility factor with the pseudo-reduced temperature, and pressure, is at least as reliable as the partial residual volume method when applied to natural gas A. In other mixtures it is possible that the relative accuracy of the two methods may be different, but in general it appears that use of Fig. 4 in the manner indicated will give results accurate within about plus or minus 1 percent, which is entirely satisfactory for all present engineering computations.

TABLE 4

Accuracy of Residual Partial Volume and Compressibility Factor Methods for Computing the Volume of Natural Gas, A

1 *Temperature °F.*	2 *Pseudo-reduced temperature T_r*	3 *Pressure, lb. per sq. in., abs.*	4 *Pseudo-reduced pressure, P_r*	5 *Compressibility factor, from Fig. 4, Z*	6 *Experimental volume, cu. ft. per lb.*	7 *Volume calculated by method of residual partial volume of Sage and Lacey, cu. ft. per lb.*	8 *Volume calculated from Z, from Fig. 4, cu. ft. per lb.*	9 *Deviation of (7) from experimental value, percent*	10 *Deviation of (8) from experimental value, percent*
100	1.425	500	0.749	0.911	0.5300	0.5335	0.5349	+ 0.66	+ 0.92
		1000	1.497	0.827	0.2412	0.2414	0.2431	+ 0.08	+ 0.79
		2000	2.995	0.724	0.1064	0.1065	0.1064	+ 0.09	+ 0.00
		3000	4.492	0.746	0.0736	0.0700	0.0732	— 4.9	— 0.54
160	1.576	500	0.749	0.937	0.6063	0.6037	0.6085	— 0.43	+ 0.36
		1000	1.497	0.882	0.2856	0.2843	0.2870	— 0.46	+ 0.49
		2000	2.995	0.814	0.1326	0.1317	0.1324	— 0.68	— 0.15
		3000	4.492	0.817	0.0892	0.0872	0.0885	— 2.2	— 0.78
220	1.729	500	0.749	0.957	0.6803	0.6742	0.6817	— 0.90	+ 0.21
		1000	1.497	0.919	0.3282	0.3232	0.3280	— 1.5	— 0.06
		2000	2.995	0.875	0.1569	0.1547	0.1563	— 1.4	— 0.38
		3000	4.492	0.869	0.1051	0.1026	0.1035	— 2.4	— 1.52

Catenary pull-rod line spanning a creek bed

By
K. C. SCLATER
Editor

A Method of Installing Catenary Pull-Rod Lines

Catenary rod-line systems reduce friction and power losses, and field procedure for their proper installation need not be involved

ROD-LINE pumping systems can be a source of power loss the extent of which is not generally realized. This may seem surprising in view of the fact that rod-line pumping is usually employed on properties where the need for operating economy is perhaps greatest.

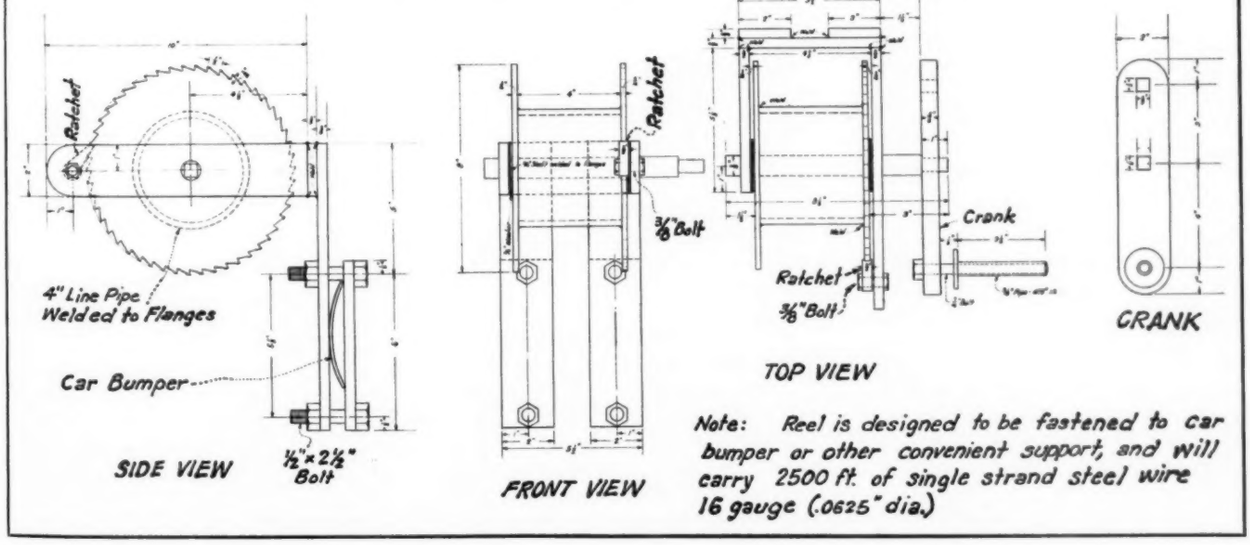
Slonneger[1] found that, by measuring the difference in work per stroke at the jack and at the knock-off post, the friction of the rod line on the average installation was 20 percent, or one-fifth, of the rod-line weight. The same authority also states that roller rod-line carriers or well-constructed catenary rod lines reduce the friction to as little as one-fourth this amount; that is, a reduction from 20 percent to 5 percent of the rod-line weight.

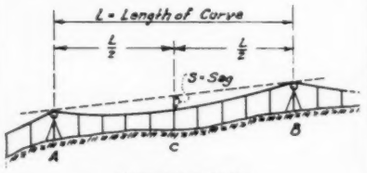
Attention has also been drawn to the use of catenary rod lines for reducing friction, by Bridges[2]. He states that dynamometer tests show that a conservative average rod-line friction is about 30 percent of the rod-line weight, and that the friction is only about 10 to 20 percent of the rod-line weight when doll heads are freshly greased, but increases to 50-60 percent after the grease has practically worn off. Two adjacent leases are cited by Bridges, each of which was pumped from its own central bandwheel power and using conventional rod-line systems. They were re-equipped with rod lines with catenary sags and pumped from a new power centrally situated with respect to both leases. Dynamometer charts were made of all wells

[1] "Back-Crank Problems and Rod-Line Pumping," by J. C. Slonneger. A.P.I. *Drilling and Production Practice*, 1938.

[2] "Back-Side Crank Pumping and Catenary Rod Lines," by R. E. Bridges. A.P.I. *Drilling and Production Practice*, 1936.

Details of utility wire-line reel used for setting catenary rod lines





EXPLANATION

After having determined the maximum rod-line pull, measure the distance L (length of curve), then stretch wire line between points A and B at the height of the rod line and allow wire to sag at midpoint C of the curve, the amount shown under S in table.

EXAMPLE: Assume a maximum rod-line pull, P, of 12,000 lb., pull rods ⅞ in., and distance L of 350 ft.

Now refer to Table. Under Table for a maximum rod-line pull P = 12,000 lb., find opposite 350 ft. in ⅞-column under S, 2 ft. 10½ in. This is the allowable sag for the assumed conditions.

The values in the Tables are calculated from the parabolic formula:

$$wx^2 = Py$$

where:

w = weight of rod line in lb./ft.
x = half the distance, L, in ft.
P = maximum rod-line pull in lb.
y = amount of sag, S, in ft.

This formula approaches a true catenary when the sag, S, is less than 10 percent of the distance, L.

P = 4,000 lb.

S = Sag

Stake No.	Length of Curve L	Diameter of Pull Rod 5/8"	3/4"	7/8"	
1	25	0 1/4"	0 1/4"	0 1/4"	
2	50	1 1/4"	1 1/4"	2 3/8"	
3	75	2 1/2"	3 3/8"	4 1/4"	
4	100	4 1/4"	6"	8 3/8"	
5	125	7 3/8"	9 3/8"	1'-1 1/4"	
6	150	10 3/8"	1'-1 1/2"	1'-7"	
7	175	1'-1 3/4"	1'-6 3/8"	2'-1 3/4"	
8	200	1'-6"	2'-0"	2'-9 1/2"	
9	225	1'-10 1/4"	2'-6 3/8"	3'-6 3/4"	
10	250	2'-4 1/8"	3'-1 1/2"	4'-4 5/8"	
11	275	2'-10 1/8"	3'-9 3/8"	5' 3 1/2"	
12	300	3'-4 1/2"	4'-6"	6'-4"	
13	325	3'-11 1/2"	5'-3 3/8"	7'-5 1/8"	
14	350	4'-7 1/2"	6'-1 1/2"	8'-7 1/2"	
15	375	5'-3 1/4"	7'-0 3/8"	9'-10 3/8"	
16	400	6'-0"	8'-0"	11'-3"	
17	425	6'-9 1/4"	9'-0 3/8"	12'-8 3/8"	
18	450	7'-7 1/8"	10'-1 1/2"	14'-2 3/8"	
19	475	8'-5 1/2"	11'-3 3/8"	15'-10 1/2"	
20	500	9'-4 1/2"	12'-6"	17'-7"	
21	525	10'-4 3/8"	13'-9 3/8"	19'-4 1/2"	
22	550	11'-4 3/8"	15'-1 1/2"	21'-3 1/2"	
23	575	12'-4 1/4"	16'-6 3/8"	23'-3"	
24	600	13'-6"	18'-0"	25'-3 3/8"	

P = 5,000 lb.

S = Sag

Stake No	Length of Curve L	Diameter of Pull Rod 5/8"	3/4"	7/8"	
1	25	0 1/4"	0 1/2"	0 1/2"	
2	50	1"	1 1/4"	1 5/8"	
3	75	2"	2 3/4"	3 3/8"	
4	100	3 3/8"	4 3/4"	6 3/4"	
5	125	5 3/8"	7 1/2"	10 1/2"	
6	150	8 3/8"	10 3/4"	1'-3 1/4"	
7	175	11"	1'-2 1/2"	1'-8 5/8"	
8	200	1'-2 3/8"	1'-7 1/2"	2'-3"	
9	225	1'-6 1/4"	2'-0 3/8"	2'-10 1/2"	
10	250	1'-10 1/8"	2'-6"	3'-6 1/4"	
11	275	2'-3 1/4"	3'-0 3/8"	4'-3"	
12	300	2'-8 3/8"	3'-7 1/2"	5'-0 3/8"	
13	325	3'-2"	4'-2 3/4"	5'-11 1/4"	
14	350	3'-8 1/2"	4'-10 1/4"	6'-10 3/8"	
15	375	4'-2 5/8"	5'-7 1/2"	7'-10 1/2"	
16	400	4'-9 3/8"	6'-4 3/4"	9'-0"	
17	425	5'-5"	7'-2 3/4"	10'-1 3/8"	
18	450	6'-1"	8'-1 1/2"	11'-4 3/8"	
19	475	6'-9 1/4"	9'-0 3/8"	12'-8 1/4"	
20	500	7'-6"	10'-0"	14'-0 3/8"	
21	525	8'-3 1/4"	11'-0 3/8"	15'-6"	
22	550	9'-1"	12'-1 1/2"	17'-0 1/4"	
23	525	9'-11"	13'-2 3/4"	18'-7 1/8"	
24	600	10'-9 3/8"	14'-4 1/2"	20'-3"	

P = 6,000 lb.

S = Sag

Stake No	Length of Curve L	Diameter of Pull Rod 5/8"	3/4"	7/8"	1"
1	25	0 1/4"	0 1/4"	0 1/2"	0 1/2"
2	50	0 1/2"	1"	1 1/2"	1 3/4"
3	75	1 3/8"	2 1/4"	3 1/2"	4 5/8"
4	100	3"	4"	5 3/8"	7 1/8"
5	125	4 5/8"	6 1/4"	8 3/4"	11 3/8"
6	150	6 3/4"	9"	1'-0 3/8"	1'-4 1/2"
7	175	9 1/2"	1'-0 1/4"	1'-5 1/2"	1'-10 3/8"
8	200	1'-0"	1'-4"	1'-10 1/2"	2'-5 3/8"
9	225	1'-3 1/4"	1'-8 1/4"	2'-4 1/2"	3'-1"
10	250	1'-6 3/8"	2'-1"	2'-11 1/2"	3'-9 5/8"
11	275	1'-10 1/8"	2'-6 1/4"	3'-6 5/8"	4'-7 1/2"
12	300	2'-3"	3'-0"	4'-2 5/8"	5'-5 5/8"
13	325	2'-7 5/8"	3'-6 1/4"	4'-11 3/8"	6'-5 3/4"
14	350	3'-0 3/4"	4'-1"	5'-8 1/2"	7'-5 3/8"
15	375	3'-6 1/4"	4'-8 1/4"	6'-7 3/8"	8'-6 1/4"
16	400	4'-0"	5'-4"	7'-6"	9'-8 1/4"
17	425	4'-6 1/2"	6'-0 1/4"	8'-5 3/8"	10'-11 1/2"
18	450	5'-0 3/4"	6'-9"	9'-5 1/2"	12'-3 1/2"
19	475	5'-7 5/8"	7'-6 1/4"	10'-7"	13'-8 1/4"
20	500	6'-3"	8'-4"	11'-8 5/8"	15'-2 1/2"
21	525	6'-10 5/8"	9'-2 1/4"	12'-11"	16'-9 1/2"
22	550	7'-6 3/4"	10'-1"	14'-2 3/8"	18'-4 1/2"
23	575	8'-3 1/4"	11'-0 1/4"	15'-6"	20'-1 1/2"
24	600	9'-0"	12'-0"	16'-10 1/2"	21'-10 3/8"

P = 8,000 lb.

S = Sag

Stake No.	Length of Curve L	Diameter of Pull Rod 5/8"	3/4"	7/8"	1"
1	25	0 1/2"	0 1/2"	0 1/2"	0 5/8"
2	50	0 3/4"	0 3/4"	1 1/8"	1 3/8"
3	75	1 3/8"	1 3/4"	2 3/8"	3 1/8"
4	100	2 1/2"	3"	4 1/2"	5 1/2"
5	125	3 1/2"	4 5/8"	6 5/8"	8 1/2"
6	150	5"	6 1/2"	9 1/2"	1'-0 3/4"
7	175	6 3/4"	9 1/4"	1'-1"	1'-4 1/4"
8	200	9"	1'-0"	1'-4 3/8"	1'-9 3/8"
9	225	11 3/8"	1'-3 1/4"	1'-9 1/8"	2'-3 1/4"
10	250	1'-2"	1'-6 3/4"	2'-2 1/8"	2'-10 3/8"
11	275	1'-5"	1'-10 1/8"	2'-7 1/8"	3'-5 3/8"
12	300	1'-8 1/4"	2'-3"	3'-1 3/8"	4'-1 5/8"
13	325	1'-11 1/2"	2'-7 1/8"	3'-8 1/2"	4'-9 3/8"
14	350	2'-3 1/8"	3'-0 1/4"	4'-3 1/4"	5'-7 1/8"
15	375	2'-7 1/8"	3'-6 1/4"	4'-11 1/4"	6'-5"
16	400	3'-0"	4'-0"	5'-7 1/2"	7'-3 1/2"
17	425	3'-4 1/8"	4'-6 1/4"	6'-4 1/2"	8'-2 3/8"
18	450	3'-9 1/8"	5'-0 1/4"	7'-1 1/2"	9'-2 3/8"
19	475	4'-2 1/2"	5'-7 1/8"	7'-11 1/8"	10'-3 1/8"
20	500	4'-8 1/2"	6'-3"	8'-9 1/2"	11'-4 3/8"
21	525	5'-2"	6'-10 1/8"	9'-8 1/4"	12'-7"
22	550	5'-8"	7'-6 1/4"	10'-7 1/2"	13'-9 1/8"
23	575	6'-2 3/8"	8'-3 1/4"	11'-7 1/4"	15'-1 1/4"
24	600	6'-9"	9'-0"	12'-7 3/8"	16'-5"

P = 10,000 lb.

S = Sag

Stake No.	Length of Curve L	Diameter of Pull Rod 5/8	3/4"	7/8"	1"
1	25	0 1/2"	0 1/2"	0 1/2"	0 1/2"
2	50	0 1/2"	0 3/4"	0 3/4"	1 1/8"
3	75	1"	1 3/8"	1 3/4"	2 1/4"
4	100	1 3/4"	2 3/8"	3 3/8"	4 1/4"
5	125	2 1/2"	3 1/2"	5 1/4"	6 5/8"
6	150	4 1/8"	5 3/8"	7 1/2"	9 1/2"
7	175	5 1/2"	7 1/8"	10 3/8"	1'-1 1/2"
8	200	7 1/4"	9 1/2"	1'-1 1/2"	1'-5 1/2"
9	225	9 1/2"	1'-1 1/8"	1'-5"	1'-10 1/4"
10	250	11 1/2"	1'-3"	1'-9 1/2"	2'-3 3/8"
11	275	1'-1 1/2"	1'-6 1/8"	2'-1 1/2"	2'-9 5/8"
12	300	1'-4 1/2"	1'-9 5/8"	2'-6 1/8"	3'-3 1/2"
13	325	1'-7"	2'-1 3/8"	2'-11 5/8"	3'-10 3/8"
14	350	1'-10 1/8"	2'-5 1/2"	3'-5 1/4"	4'-5 5/8"
15	375	2'-1 1/8"	2'-9 1/4"	3'-11 3/8"	5'-1 1/8"
16	400	2'-4 1/2"	3'-2 1/8"	4'-6"	5'-10 1/2"
17	425	2'-8 1/2"	3'-7 1/8"	5'-1"	6'-7 1/2"
18	450	3'-0 1/2"	4'-0 1/8"	5'-8 1/8"	7'-4 1/2"
19	475	3'-4 1/2"	4'-6 1/8"	6'-4 1/8"	8'-2 1/8"
20	500	3'-9"	5'-0"	7'-0 1/2"	9'-1 1/2"
21	525	4'-1 1/2"	5'-6 1/8"	7'-9"	10'-0 1/2"
22	550	4'-6 1/2"	6'-0 1/2"	8'-6 1/8"	11'-0 1/2"
23	575	4'-11 1/2"	6'-7 1/8"	9'-3 1/2"	12'-0 1/2"
24	600	5'-4 1/2"	7'-2 1/2"	10'-1 1/2"	13'-1 1/2"

Tables showing amount of sag in catenary rod lines for different conditions

before and after the new installation. A reduction in horsepower of 19.5 percent was obtained, despite the fact that 32 percent more pull rods were used.

Realizing the advantages of catenary rod lines, one large company is, wherever possible, installing catenary rod-line systems, for facilitating the laying-out of which its petroleum engineering staff has worked out a simple and quick method.

The accompanying set of tables was made up for field use, from the parabolic formula,

$$wx^2 = 2Py$$

in which:

w = weight of rod line in lb./ft.
x = half the distance L in ft.
P = maximum rod-line pull in lb.
y = amount of sag, S, in ft.

This formula is close enough for all practical purposes in laying-out catenary rod lines, even on steep slopes, as it approaches the true catenary when the sag is less than 10 percent of the span.[2]

The maximum rod-line pull (at the knock-off post) consists of maximum well (polished-rod) load, plus the maximum rod-line friction and the rod-line inertia.[1] Differences in elevation of the knock-off post and the jack may also be allowed for on the basis of the elevation divided by the line distance and multiplied by the weight of the rod line. This gives the net rod-

P = 12,000 lb.

S = Sag

Stake No.	Length of Curve L	Diameter of Pull Rod			
		5/8"	3/4"	7/8"	1"
1	25	0 3/8"	0 5/8"	0 1"	0 1 1/4"
2	50	0 1 1/2"	0 2 1/2"	0 3 1/4"	1"
3	75	0 3 3/8"	1 5/8"	1 1 1/2"	2"
4	100	1 2 1/2"	2"	2 3 1/4"	3 1/2"
5	125	2 1 3/4"	3 1/2"	4 1 1/2"	5 1/4"
6	150	3 1 1/8"	4 2 1/2"	6 1/8"	8 3/4"
7	175	4 1/2"	6 3/8"	8 1/4"	11 1/2"
8	200	6"	8"	11 1/4"	1'-2 3/4"
9	225	7 1/2"	10 1/8"	1'-2 1/4"	1'-6 1/2"
10	250	9 1/8"	1'-0 1/2"	1'-5 1/2"	1'-10 3/4"
11	275	11 1/8"	1'-3 1/2"	1'-9 1/2"	2'-3 1/2"
12	300	1'-1 1/2"	1'-6"	2'-1 1/8"	2'-8 1/4"
13	325	1'-3 11/16"	1'-9 1/8"	2'-5 3/8"	3'-2 3/4"
14	350	1'-6 3/8"	2'-0 1/2"	2'-10 1/2"	3'-8 3/4"
15	375	1'-9 1/8"	2'-4 1/8"	3'-3 5/8"	4'-3 1/2"
16	400	2'-0"	2'-8"	3'-9"	4'-10 1/2"
17	425	2'-3 1/8"	3'-0 1/8"	4'-2 3/8"	5'-6"
18	450	2'-6 3/8"	3'-4 1/2"	4'-9"	6'-1 7/8"
19	475	2'-9 7/8"	3'-9"	5'-3 1/8"	6'-10 1/2"
20	500	3'-1 1/2"	4'-2"	5'-10 3/8"	7'-7 1/4"
21	525	3'-5 1/2"	4'-7 1/8"	6'-5 1/4"	8'-4 1/8"
22	550	3'-9 7/8"	5'-0 1/4"	7'-1 1/8"	9'-2 1/8"
23	575	4'-1 1/8"	5'-6"	7'-9"	10'-0 3/4"
24	600	4'-6"	6'-0"	8'-5 1/4"	10'-11 3/8"

P = 15,000 lb.

S = Sag

Stake No.	Length of Curve L	Diameter of Pull Rod			
			3/4"	7/8"	1"
1	25		0 3/8"	0 1/2"	0 1 1/4"
2	50		0 1 3/8"	0 2 1/4"	0 3 1/4"
3	75		0 3 1/8"	1 3/8"	1 1 3/4"
4	100		1 2 1/2"	2 1/4"	2 3 1/4"
5	125		2 1 1/2"	3 1/2"	4 1/2"
6	150		3 1/8"	5"	6 1/8"
7	175		4 3 1/4"	6 1/8"	8 1/2"
8	200		6 1/8"	9"	11 3/4"
9	225		8"	11 3/8"	1'-2 3/4"
10	250		10"	1'-2"	1'-6 1/4"
11	275		1'-0 1/2"	1'-5"	1'-10 1/2"
12	300		1'-2 3/8"	1'-8 1/4"	2'-2 1/4"
13	325		1'-4 3/8"	1'-11 1/4"	2'-6 1/2"
14	350		1'-7 1/2"	2'-3 1/4"	2'-11 3/4"
15	375		1'-10 1/2"	2'-7 3/8"	3'-5"
16	400		2'-1 1/2"	3'-0"	3'-10 5/8"
17	425		2'-4 3/8"	3'-4 3/8"	4'-4 3/8"
18	450		2'-8 1/8"	3'-9 3/8"	4'-11"
19	475		3'-0 1/8"	4'-2 3/4"	5'-5 3/8"
20	500		3'-4"	4'-8 1/4"	6'-1"
21	525		3'-8"	5'-2"	6'-8 3/8"
22	550		4'-0 1/8"	5'-8"	7'-4 3/8"
23	575		4'-4 3/4"	6'-2 1/8"	8'-0 1/2"
24	600		4'-9 1/8"	6'-9"	8'-9 7/8"

P = 17,500 lb

S = Sag

Stake No.	Length of Curve L	Diameter of Pull Rod			
			3/4"	7/8"	1"
1	25		0 1/2"	0 5/8"	0 1 1/4"
2	50		0 1 1/8"	0 1 1/2"	0 2 1/4"
3	75		0 2 3/4"	1 1/8"	1 1 1/2"
4	100		1 1 3/8"	1 1/8"	2 1/2"
5	125		2 1/8"	3"	4"
6	150		3 1/8"	4 1/8"	5 1/8"
7	175		4 1/4"	5 3/8"	7 1/8"
8	200		5 1/2"	7 1/8"	10"
9	225		7"	9 1/4"	1'-0 5/8"
10	250		8 1/2"	1'-0"	1'-3 5/8"
11	275		10 1/2"	1'-2 3/8"	1'-7"
12	300		1'-0 3/8"	1'-5 3/8"	1'-10 1/2"
13	325		1'-2 1/2"	1'-8 3/8"	2'-2 3/8"
14	350		1'-4 3/8"	1'-11 5/8"	2'-6 5/8"
15	375		1'-7 3/8"	2'-3 1/2"	2'-11 3/8"
16	400		1'-10"	2'-6 7/8"	3'-4 1/2"
17	425		2'-0 7/8"	2'-10 3/4"	3'-9 1/8"
18	450		2'-3 3/8"	3'-3"	4'-2 3/8"
19	475		2'-7"	3'-7 1/2"	4'-8 3/8"
20	500		2'-10 3/8"	4'-0 1/4"	5'-2 1/2"
21	525		3'-1 3/4"	4'-5 3/8"	5'-8 3/8"
22	550		3'-5 1/2"	4'-10 3/8"	6'-3 3/4"
23	575		3'-9 7/8"	5'-3 7/8"	6'-10 5/8"
24	600		4'-1 3/8"	5'-9 1/2"	7'-6 3/8"

P = 20,000 lb.

S = Sag

Stake No	Length of Curve L	Diameter of Pull Rod			
				7/8"	1"
1	25			0 1/2"	0 5/8"
2	50			0 1 1/2"	0 2 1/8"
3	75			1"	1 1/4"
4	100			1 1/2"	2 1/8"
5	125			2 1/8"	3 1/2"
6	150			3 1/8"	4 1/2"
7	175			5 1/8"	6 1/4"
8	200			6 3/4"	8 3/4"
9	225			8 1/2"	11"
10	250			10 1/2"	1'-1 3/8"
11	275			1'-0 3/4"	1'-4 1/2"
12	300			1'-3 1/4"	1'-7 7/8"
13	325			1'-5 7/8"	1'-11 1/8"
14	350			1'-8 5/8"	2'-2 1/8"
15	375			1'-11 3/4"	2'-6 3/4"
16	400			2'-3"	2'-11"
17	425			2'-6 1/2"	3'-3 1/2"
18	450			2'-10 1/4"	3'-8 3/8"
19	475			3'-2 1/8"	4'-1 1/2"
20	500			3'-6 1/4"	4'-6 3/4"
21	525			3'-10 1/2"	5'-0 3/8"
22	550			4'-3"	5'-6 1/2"
23	575			4'-7 3/4"	6'-0 3/8"
24	600			5'-0 3/4"	6'-6 1/2"

P = 25,000 lb.

S = Sag

Stake No	Length of Curve L	Diameter of Pull Rod			
				7/8"	1"
1	25			0 5/8"	0 3/4"
2	50			0 1 3/4"	0 2 1/4"
3	75			0 3 1/4"	1"
4	100			1 1/8"	1 1/4"
5	125			2 1/8"	2 3/4"
6	150			3"	4"
7	175			4 5/8"	5 1/2"
8	200			5 1/2"	7"
9	225			6 3/4"	8 3/4"
10	250			8 3/8"	10 3/8"
11	275			10 1/4"	1'-1 1/4"
12	300			1'-0 1/8"	1'-3 3/4"
13	325			1'-2 1/4"	1'-6 1/2"
14	350			1'-4 1/2"	1'-9 1/2"
15	375			1'-7"	2'-0 5/8"
16	400			1'-9 5/8"	2'-4 3/4"
17	425			2'-0 3/8"	2'-7 3/8"
18	450			2'-3 3/8"	2'-11 1/2"
19	475			2'-6 1/2"	3'-3 1/2"
20	500			2'-9 1/4"	3'-7 3/4"
21	525			3'-1 1/4"	4'-0 1/4"
22	550			3'-4 3/4"	4'-5"
23	575			3'-8 1/4"	4'-10"
24	600			4'-0 5/8"	5'-3 1/2"

P = 30,000 lb.

S = Sag

Stake No.	Length of Curve L	Diameter of Pull Rod			
				7/8"	1"
1	25			0 1/2"	0 3/4"
2	50			0 1 1/2"	0 2 1/8"
3	75			0 2 1/2"	0 3 1/4"
4	100			1 1/8"	1 1/2"
5	125			1 1/2"	2 1/4"
6	150			2 1/8"	3 1/4"
7	175			3 1/8"	4 1/8"
8	200			4 1/8"	5 1/8"
9	225			5 1/8"	7 1/8"
10	250			7 1/8"	9 1/8"
11	275			8 1/8"	11"
12	300			10 1/8"	1'-1 1/8"
13	325			11 1/8"	1'-3 1/8"
14	350			1'-1 1/8"	1'-5 1/8"
15	375			1'-3 1/8"	1'-8 1/2"
16	400			1'-6"	1'-11 1/8"
17	425			1'-8 1/4"	2'-2 1/8"
18	450			1'-10 1/2"	2'-5 1/2"
19	475			2'-1 1/8"	2'-8 5/8"
20	500			2'-4 1/8"	3'-0 1/2"
21	525			2'-7"	3'-4 1/4"
22	550			2'-10 1/8"	3'-8 1/2"
23	575			3'-1 1/4"	4'-0 1/4"
24	600			3'-4 1/2"	4'-4 1/2"

Tables showing amount of sag in catenary rod lines for different conditions

line component force, and should be added to or subtracted from the rod-line pull according to whether it increases or diminishes the forces involved. But ordinarily this calculation can be disregarded.[1]

Maximum Well Load

If the wells have not been weighed the maximum polished-rod load may be calculated from the A.P.I. suggested method for computing well loads.[3]

[3] "Rating of Speed Reducers for Pumping Machines," A.P.I. Standards No., 11-E, Third Edition, September, 1938.

$$P = (W_r + W_o)\ (1 + \frac{S \times \overline{SPM})}{5400}$$

Where

NL = net peak polished-rod load

NL = 0.4 P or NL = P—CB Actual) whichever is larger

P = total peak polished-rod load

W_r = weight of rod string neglecting buoyancy

W_o = weight of oil
$= 0.34\ D^2 \times L$

D = effective diameter of plunger, in inches

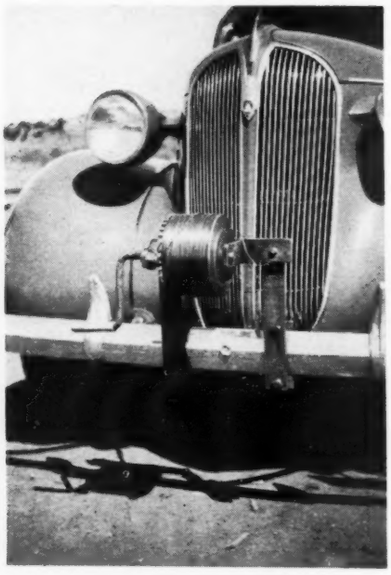
L = depth to pump, in feet

S = polished-rod stroke, in inches

$\overline{SPM}$ = strokes per minute

CB Actual = Actual effective counterbalance force

Peak torque is assumed equal to NL



Utility wire-line reel attached to car bumper

Catenary pull-rod line on fairly level ground

× half the polished-rod stroke length.

Bridges[2] suggests that it is good practice to increase the maximum well load 10 to 15 percent to provide for additional weight that might be caused by tight plungers, greater jack ratio, or other such contingency. If paraffin is present the maximum well load should be increased 60 to 70 percent to provide for additional load resulting from paraffin deposition in the tubing.

Rod-Line Friction

The rod-line friction may be taken as 20 percent of the rod-line weight.

Rod-Line Inertia

The rod-line inertia[1] is:

$$F_i = w\left(\frac{1}{J}\right)\frac{(s \times s.p.m.)}{5400}$$

where:

F_i = rod-line inertia in lb.

w = weight of rod line in lb.

J = ratio of polished-rod stroke/rod-line stroke

s = polished-rod stroke in ft.

s.p.m. = no. of strokes per minute

Having the maximum rod-line pull, the necessary sag can be read direct from the table when the distance L is observed.

Changes in vertical direction should not be too abrupt. Bridges[2] suggests an angle not to exceed 5 to 6 degrees on heavy wells and 6 to 8 on light wells; however, this angle should be governed by the size of the rods and the properties of the metal of which they are made. Flexing beyond the elastic limit may result in fatigue and early failure of the rod.

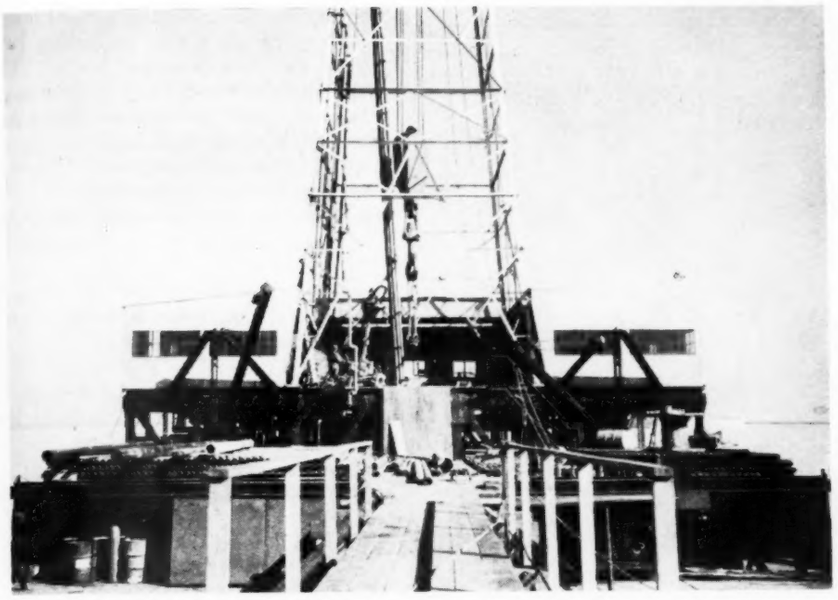
Lengths of catenary curves will be governed by the topography. In a field in West Texas, a catenary distance as great as 700 ft. is being used on a rod line.

In setting stakes for rod-line supports, a wire-line reel that attaches to the front bumper has been found very convenient for field use. One man has been able to lay-out a rod-line system with reasonable speed after he has acquired the knack of coördinating his work of setting stakes and obtaining the proper sag by means of the tables.

Old (non-catenary) rod line

Method of supporting catenary rod line spanning a creek bed

P 422.912.5



72-ft. by 145-ft. drilling barge viewed from deck of boiler barge

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

By
H. LEE FLOOD
Associate Editor

Largest Submersible Drilling Barge Combines Best Features of Marine Design

Barge is designed to maintain stability when 12,000 ft. of 9⅝-in. casing is suspended in hole and 14,000 ft. of 4½-in. drill pipe is standing in derrick—300-lb. superheated steam drives equipment—two drawworks are installed

SINCE the first submersible drilling barges were employed in this country approximately six years ago, their use has become an accepted practice, particularly in the Gulf Coast areas of Louisiana and Texas. Judging by developments in the last several months, when more new barges have been completed or begun than during any previous like period, marine drilling from barges is only now entering the truly active stage.

Typifying the progress that marks nearly every development in the oil industry, each barge constructed has incorporated new improvements, different arrangements, or more suitable equipment that in one way or another has been an advance in design over its predecessors. Being contemporary with the period of unprecedented increase in drilling depths and the design of heavier, speedier drilling equipment, the span of events embracing drilling barge development has been comprised principally of additions and changes that would permit marine drilling to meet the requirements of still greater depth.

In the present article will be described a recently-completed drilling barge that can truly be called the prototype of current barge design. Completed during January at Beaumont, Texas, it is almost identical in size and appointments with a barge completed last October by the same builders for another company. These two barges represent the largest vessels that have yet been constructed for deep-drilling purposes. Both are equipped to be operated by steam, supplied by boilers mounted on smaller, companion barges. Both have comparable drilling equipment. Perhaps the greatest difference between the two is that the boilers on the earlier barge generate superheated steam at 350-lb. working pressure; the boilers on the newer barge provide superheated steam at 300-lb. working pressure.

Description of Drilling Barge

The complete barge follows the conventional pattern of most submersible drilling barges in that it comprises two identical hulls joined by transverse trusses to provide a slot or space between the hulls as a means of moving-off the site after the well is completed. The connecting trusses are bolted to the hulls rather than riveted or welded in place permanently, to provide a very essential feature in a barge of this size—the ability to navigate the Intercoastal Canal when necessary. Moves requiring use of the canal will be infrequent but they will require that each half, i.e., each hull of the barge, be towed separately. The drilling derrick will, of course, have to be dismantled during the move. At the present time, the barge is rigged-up on its first job in a lake south of Jennings, Louisiana, and it is not expected that it will be necessary to move from this body of water for possibly two years.

Each hull measures 32 ft. in width by 145 ft. in length by 10 ft. in height. When joined together, an 8-ft. slot is maintained between the hulls so that the overall area of the barge is 72 ft. by 145 ft., or 10,440 sq. ft. The structural-steel framework of each hull is completely sheathed by steel plate to form the sides, the flat deck, and flat bottom.

Plates having a thickness of 5/16 in. are used as the decks; ⅜-in. plates are used as the bottom, and the side plates are ½-in. in thickness. The total volume of each hull is partitioned into six water-tight compartments, thus incorporating the cell-like construction employed in the hulls of most marine vessels to guard against flooding the entire vessel in the event of ruptured plates.

The derrick floor and principal working level of the barge is 15 ft. above the deck of the hulls, supported

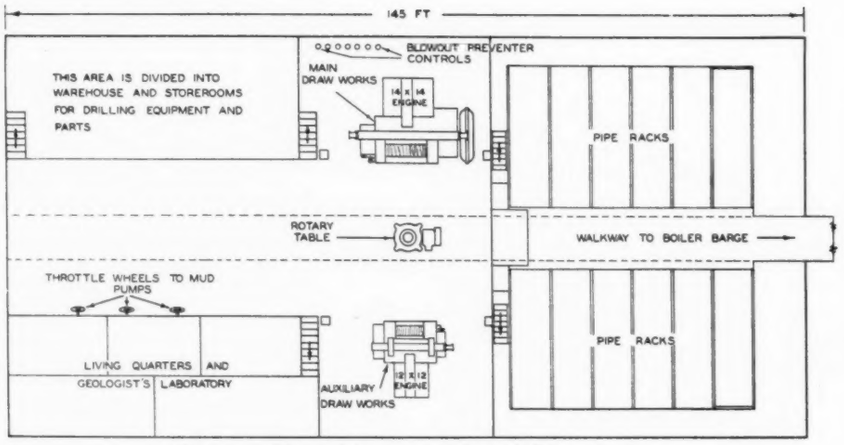

145 FT
BLOWOUT PREVENTER CONTROLS
THIS AREA IS DIVIDED INTO WAREHOUSE AND STOREROOMS FOR DRILLING EQUIPMENT AND PARTS
MAIN DRAW WORKS
14 x 14 ENGINE
PIPE RACKS
ROTARY TABLE
WALKWAY TO BOILER BARGE
THROTTLE WHEELS TO MUD PUMPS
LIVING QUARTERS AND GEOLOGIST'S LABORATORY
AUXILIARY DRAW WORKS
12 X 12 ENGINE
PIPE RACKS

Fig. 1-a. Plan of barge at derrick-floor level

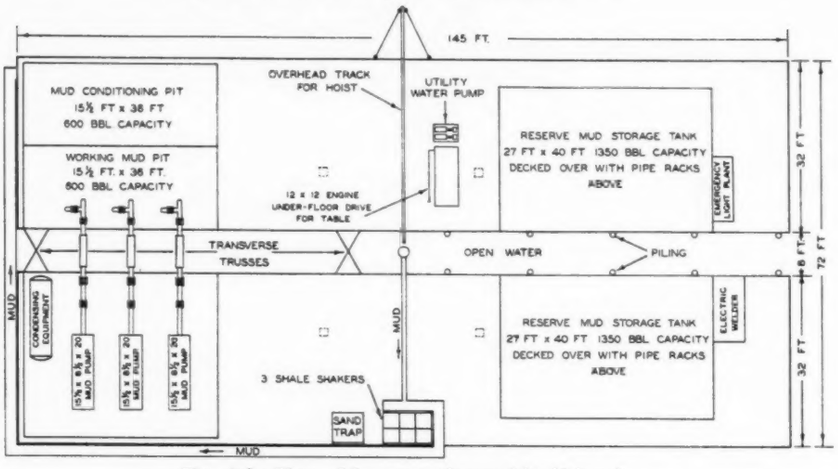

145 FT.
MUD CONDITIONING PIT 15½ FT x 38 FT 600 BBL CAPACITY
OVERHEAD TRACK FOR HOIST
UTILITY WATER PUMP
RESERVE MUD STORAGE TANK 27 FT x 40 FT 1350 BBL CAPACITY DECKED OVER WITH PIPE RACKS ABOVE
EMERGENCY LIGHT PLANT
WORKING MUD PIT 15½ FT. x 38 FT. 600 BBL CAPACITY
12 x 12 ENGINE UNDER-FLOOR DRIVE FOR TABLE
32 FT
8 FT
72 FT
TRANSVERSE TRUSSES
OPEN WATER
PILING
MUD
CONDENSING EQUIPMENT
RESERVE MUD STORAGE TANK 27 FT x 40 FT 1350 BBL CAPACITY DECKED OVER WITH PIPE RACKS ABOVE
ELECTRIC WELDER
3 SHALE SHAKERS
SAND TRAP
MUD

Fig. 1-b. Plan of barge at lower (deck) level

by the massive steel members constituting the superstructure of the barge proper. The size and strength of the craft may be gauged from the size of the principal supporting pieces; these are wide-flanged 36-in. I-beams weighing 280 lb. per linear ft. This upper floor or level occupies the entire width of the barge and extends from one end to more than half the length of the barge.

The rest of the barge deck is occupied principally by the reserve mud storage tanks, each of which is built directly on the deck plates as a base. Decked-over, the top surfaces of these tanks serve as pipe racks upon which drill-pipe and casing may be stored. Each of the tanks is 27 ft. wide by 40 ft. long by 7 ft. high, providing storage capacity of 1350 bbl., a total of 2700 bbl. of mud in the two tanks. Built flush with the inner or slot side of each hull, a 5-ft. walkway on the hull deck is provided on each outer side of the tanks. Likewise an area approximately 10 ft. wide extending across the end of the barge serves as space for the emergency light plant and for a welding "shop" including a welding generator.

The accompanying line sketches (Fig. 1) show the general arrangement of equipment and facilities on the drilling barge. Although only two levels, the deck and derrick floor, are shown, there is, in reality, a third level made-up of catwalks suspended between the two principal levels. The shale shakers, sand trap, condensing equipment, and mud trench, shown on the sketch of the deck level, are situated at this intermediate level. Likewise the catwalk shown in Fig. 2 from which the valves in the mud-pump manifold are manipulated is at this same level. The other principal "department" situated at catwalk height is the mud-conditioning platform shown in Fig. 3. On this platform, which is built over the mud-conditioning pit, is stored the mud additives adjacent to a hopper through which the additives may be introduced into the pit below.

Mud system. The two mud pits, having a total capacity of 1175 bbl. of mud, may be used as a single pit or separately by either closing or opening the gates or doors that are provided in the partition between the pits.

Each of the three mud pumps takes suction from the mud pits through a 12-in. line that is elbowed down so that the open end of the pipe is only a few inches above the pit floor. In addition to pulling suction on the mud in the pit, each pump may be used to pump lake water from the hull compartment below through a lateral connection that extends through the floor of the pit, as shown in Fig. 4. Plug valves having extension handles that may be operated from the catwalk provide for closing-off either the mud or water.

The mud suction lines bridging the slot between the two barge hulls consist of heavy-duty rubber and fabric hose clamped on both ends around the steel lines.

Just inside the steel wall of the pump pit on each suction line is a plug valve operated from the catwalk

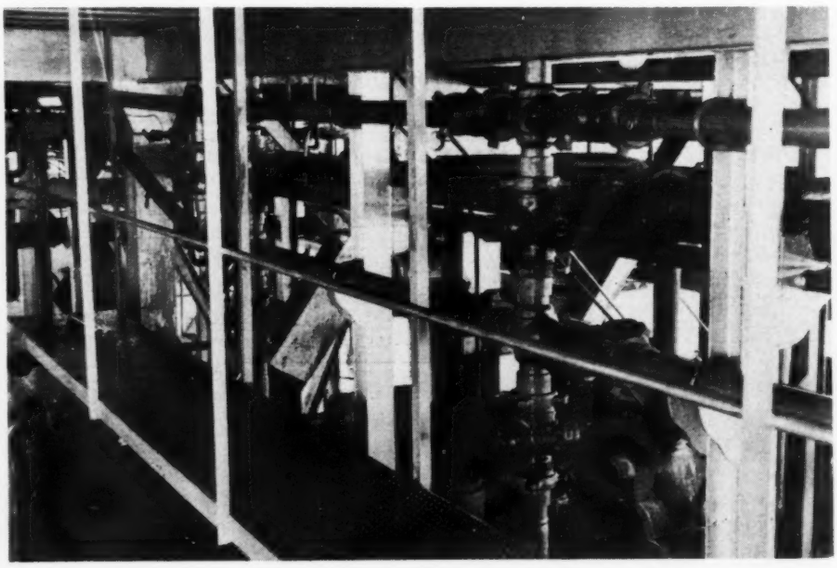


Fig 2. Catwalk and mud-pump valve manifold

Fig. 3. Mud-mixing platform

to provide a positive shut-off of the suction line on the pump side of the rubber hose section. This valve also closes-off the suction line from the pit when mud is to be pumped from the reserve tanks at the far end of the barge.

Between the plug valve and the pumps, each suction line is equipped with a special "flap" valve into the top of which is connected the line used when the pumps are compounded. Normally, the "flap" or diaphragm of the valve is held open by bolting the outside lever in the open position. When a pump is to be compounded, the flap is lowered, thereby permitting the pump to take suction from the line entering the top of the valve and also protecting the rubber suction hose from high pressure in the event of failure to close the plug valve mentioned in the preceding paragraph.

The three 15½ by 8½ by 20 mud pumps are enclosed in an open pit, the walls of which are joined to the deck to make a water-tight joint so that the barge may be sunk in water deep enough to submerge the deck if need be. The speed of each pump is controlled from the derrick floor above by an extension rod fixed to the throttle valve of the pump.

The mud-pump manifold is a masterpiece of design and arrangement. Its neat and orderly appearance may be noted in Fig. 2. In fact, the mud system as a whole is by far the most outstanding part of the entire barge. The pumps are connected and interconnected so that each of the three may be operated singly or in conjunction with either one or both of the others to perform any desired operation.

From the pumps the mud to be circulated may be pumped to either one or both of two standpipes in adjacent corners of the derrick. One of these is provided with a rubber hose; the other has a hose made-up of pipe sections joined by swivel elbows.

Mud issuing from the conductor casing is piped overhead (with respect to the deck level) to the mud trench at the shale shakers and sand trap. Three of the new-type 24-in. by 43-in. shale shakers are employed, connected by V-belts to two small steam turbines. Two of the shale shakers are used normally, one being a standby. Gates or slides in the mud trench may be used to divert the mud into any or all of the shale shakers or they may be bypassed entirely. The mud trench extends, as shown in the sketch, to the corner of the barge and across its end so that mud may be returned to either or both of the working and conditioning pits.

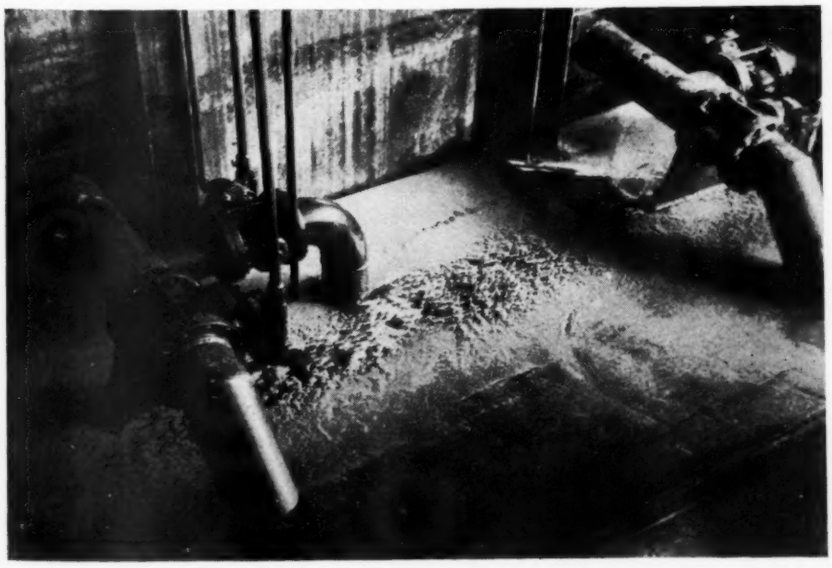


Fig. 4. Suction lines in working mud pit

Other equipment on deck level. The principal piece of drilling equipment on the barge deck is the 12 by 12 engine driving the rotary table in the underfloor-drive arrangement now being used more widely in modern drilling assemblies. The speed of this engine is controlled from the driller's stand at the main drawworks through an extension-rod system that employs a number of ball-bearing universal joints. One of the latter may be seen to the right of the column in Fig. 5. It should be mentioned that the engine is mounted on a platform approximately 3 ft. above the deck so that it, too, may be above water in the event the deck is submerged.

Set at one end of the engine is a utility pump that is used to washdown the decks or to provide water for any other purposes on the lower level.

An important labor-saver is provided on the deck level in the form of an overhead track that supports a traveling hoist used in moving blowout preventers and other heavy equipment from the barge side to the wellhead.

Drawworks. The two drawworks are situated in so-called California style—facing each other on opposite sides of the V-side of the derrick.

The main drawworks is a 3-speed machine having two 9-in. shafts, driven by a 14 by 14 engine. All gears and chains are fully-enclosed and are lubricated by force-feed so that all parts are constantly bathed by a flood of oil.

All controls are within easy reach of the driller, including pedals for speed selection and for quick reversal of the drum. The customary offset type of

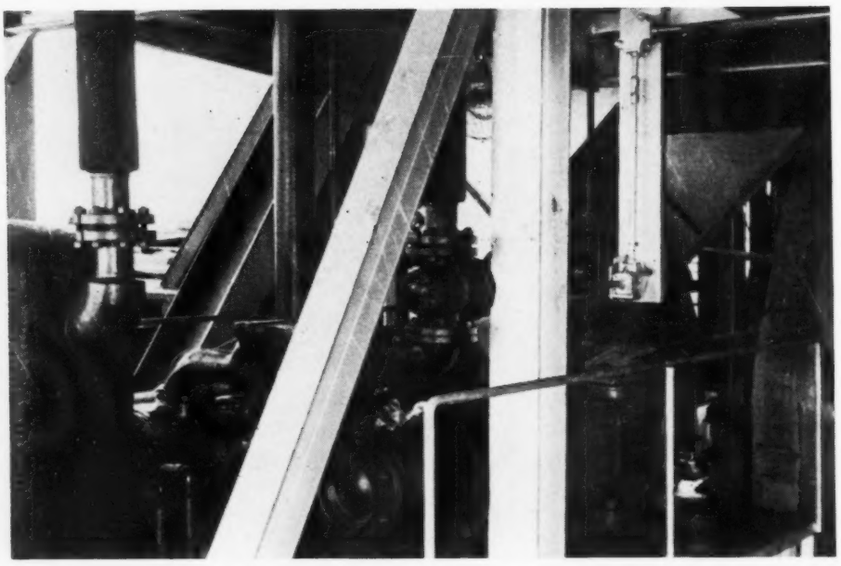


Fig. 5. This 12 by 12 engine drives the rotary table in an underfloor arrangement

extension rod to the throttle valve on the engine requiring universal joints has been eliminated. This has been accomplished by moving the valve over in line with the control wheel. The gate valve usually required for positive shut-off in addition to the throttle valve has also been eliminated by employing a type of throttle valve that also acts as an emergency shut-off valve when desired.

Not the largest drawworks built, it is, nevertheless, termed next to the largest. Incidentally, it is one that was re-built following a fire and is only newly released from the shop. The valves controlling the blowout preventers are lined-up at the rear of the engine within easy reach of the driller when needed.

The auxiliary drawworks, slightly smaller than the main drawworks, has 7½-in. shafts, one of which carries a drum on which the core-line is spooled. The "dead" end of the 1⅛-in. preformed wire line used as a drilling cable is attached to the main drum of the auxiliary drawworks in readiness for any emergency that may disable the main drawworks. With the wire thus attached, it is an easy matter to spool some of the line from time to time and avoid excessive wear on only one section of the cable. When the main drum on the auxiliary drawworks is not being operated, a heavy steel pin is dropped through a hole in the shaft to prevent it slipping and causing an accident.

Rotary table. The rotary table installed on the barge is termed the fastest table yet built. The bearings supporting the table are completely enclosed and travel in an oil bath, as do the gears connecting the table with the underfloor drive. Tested in the factory at speeds as high as 1000 r.p.m., the maximum speed recommended is 350 r.p.m. The operators plan, however, to not exceed 250 r.p.m. in normal drilling.

Living quarters. What may seem to be extensive accommodations for a drilling barge are believed warranted by the owners because of the possibility that a drilling crew may be "stranded" for several days during a severe storm.

The main room is equipped with three double-decked cots, thus providing sleeping accommodations for six crew members. A smaller room contains one double-decked cot for the use of others who may require the space. A kitchen, a mess hall, a bath room, and a room for core analysis completes the arrangement of the so-called living quarters.

Occupying the similar position on the opposite side of the barge are the store rooms for separate parts.

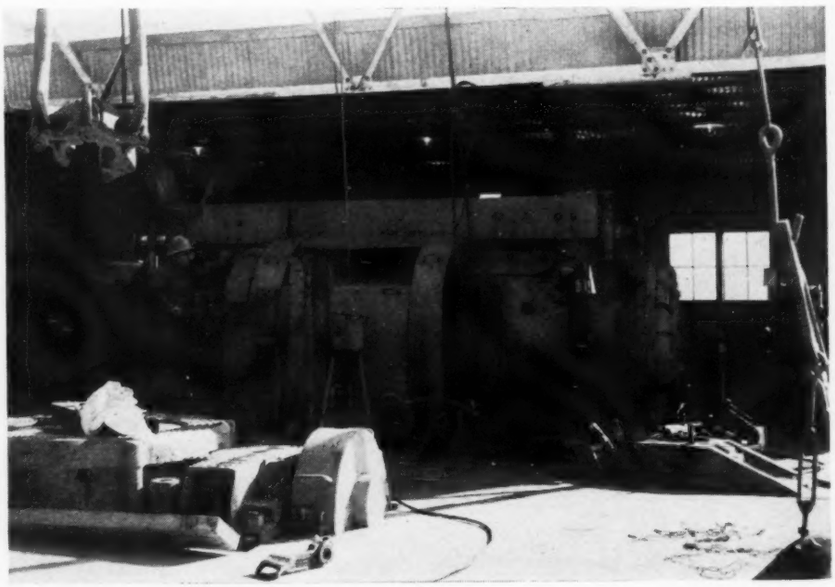
The space between the living quarters and the store rooms is open to the derrick floor and provides an ample working area adjacent to the derrick space proper.

The entire upper level is enclosed on three sides and roofed by corrugated galvanized iron on steel framework. Tentative plans call for partly enclosing the V-side of the derrick as well.

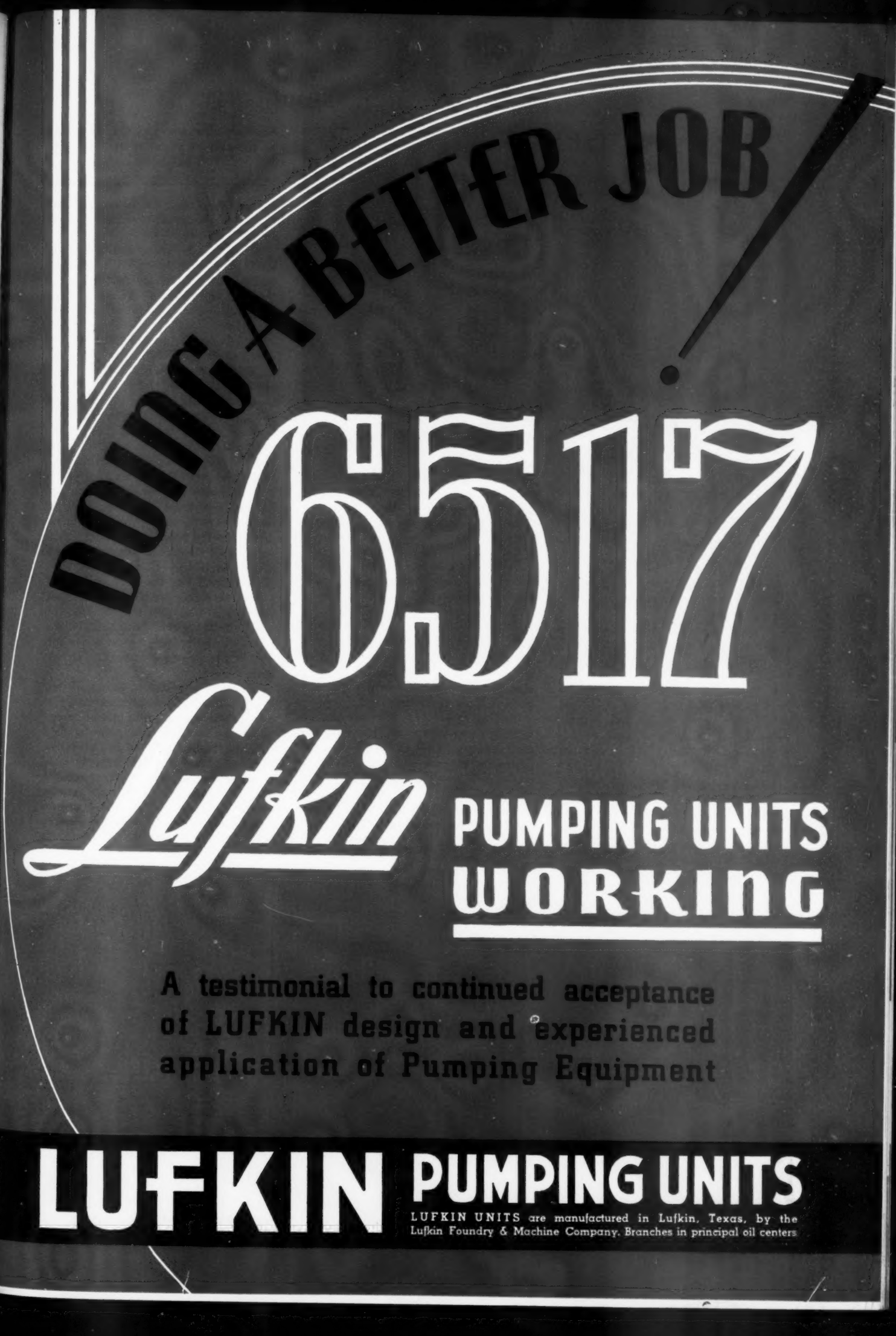
Other features of the drilling barge. One of the most useful arrangements is the piping hook-up at the base of the mud standpipe as shown in Fig. 6. The purpose of this design is to provide a means for the cementing crew to make the necessary connections at the barge side and to eliminate the need of going below to the pump room at any time during the cementing operations.

When the cementing barge ties-up alongside the drilling barge, connections are made to the two lines indicated in the sketch. In addition, steam and water are made available to the cementing crew through lines also extended to the side of the barge.

During drilling and at all times other than during a cementing job, Valve A is open and Valves B and C are closed. When cement is to be pumped-in, Valve A is closed and Valve C is opened, thereby permitting the cement pumps to deliver into the hole. When all the cement is out of the tanks, mud can be obtained for displacing the cement from the line by



Main drawworks. At time of picture, drilling line was snubbed to frame and core line was being spooled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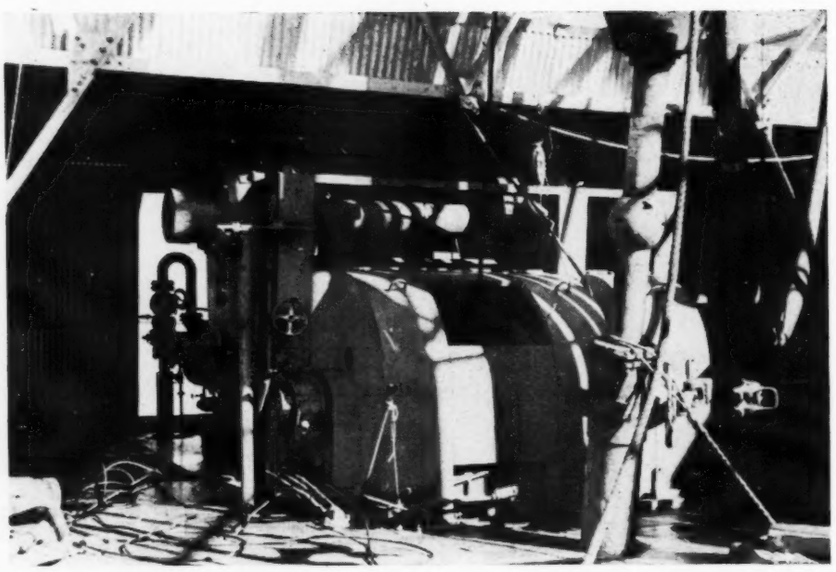


Auxiliary drawworks. Core line is to be spooled on upper shaft. Kelly is in rat hole in foreground

opening Valve B and obtaining the required amount of mud in the cement tanks.

Then, in a normal cementing job where a knowledge of the exact volume of mud is not essential, Valves B and C are closed and Valve A is again opened, permitting the mud pumps to deliver the mud required to place the cement where desired.

When it is necessary to measure the displacement mud accurately by passing through the tanks on the cement truck, Valve A in the sketch is closed and Valve B is opened to permit the mud pumps to deliver mud to the cement-truck tanks. As the mud is measured, it is then pumped from the cement tanks through Valve C into the hole.

On each side of the barge beneath the derrick floor, tanks of approximately 6 bbl. capacity are built-in to provide storage for engine oil and steam cylinder oil. The pair of tanks beneath the auxiliary drawworks provides oil for the equipment on that side of the barge and a similar pair of tanks serves the equipment opposite. Oil piping is installed so that oil is available at every essential point on the barge. Oil reservoirs on pumps and engines have a float gauge that indicates the oil level within. In addition to the use of a saponified cylinder oil as pump lubricant, the steam lines to the mud pumps are equipped with lubricators that feed graphite into the cylinders, a practice that is said to be successful where superheated steam is employed.

Among other new features in the drilling equipment is the 4½-in. unitized drill pipe used, in which the tool joints are integral with the drill pipe.

The Boiler Barge

Connected with the drilling barge by a temporary wooden walkway supported on piling, the boiler barge is similar to the larger craft in that it is submersible also.

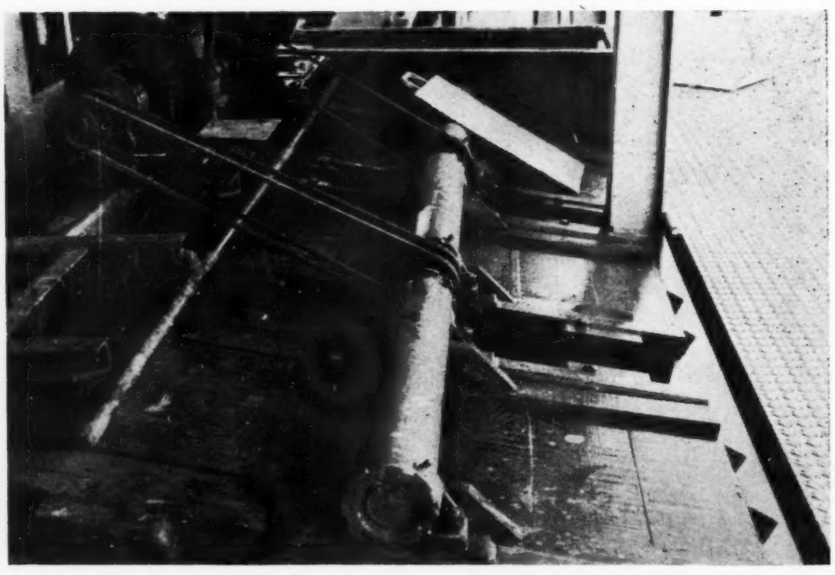
Measuring 36 ft. in width by 100 ft. in length by 10 ft. in height, the hull of the barge supports the boilers, the fuel and water tanks, and all the equipment necessary in the generation of steam.

The five oil-field-type boilers are situated on the main level, 8 ft. above the deck of the barge. Three boilers are on one end of the barge; the other two are set on the outer edges at the other end and the boiler feedwater heater is set between them. The three boiler feed pumps are set in the center of the room and the gauge board and control manifold is mounted behind the pumps.

Each pump is provided with three suction and three discharge connections. The total of 18 lines is installed just below the floor. The 18 plug valves controlling these lines are in line in a neat arrangement that includes brass plates identifying the purpose of each valve. The valves extend partly through the floor so that they may be operated easily. A glance at the markings on the stems of the valves indicates quickly which suction and discharge valves are open.

The control manifold shown in Fig. 7 is a skillful arrangement of valves to provide the maximum in ease of operation. Two curved headers, one for fuel and one for steam, are the principal parts of the assembly. Fuel to each boiler is fed through a valve having a graduated stem to aid in adjusting the fuel volume. A smaller bypass valve of

Shale shakers are mounted at catwalk level



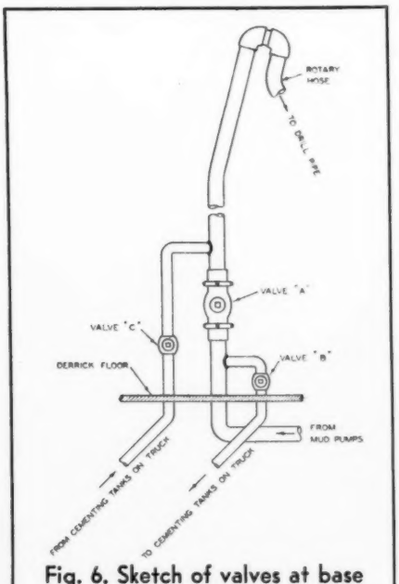
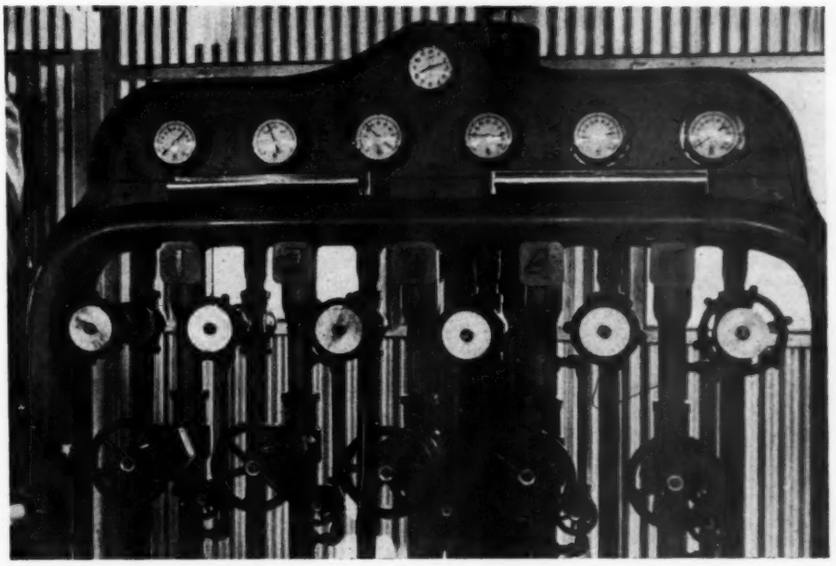


Fig. 6. Sketch of valves at base of mud standpipe

Fig. 7. Valve and gauge control board on boiler barge



the same type is used for "vernier" adjustments of the fuel.

A similar arrangement of the valves from the steam header permits easy and accurate adjustment of the speed of any one of the pumps.

The boilers are equipped to generate superheated steam at 300-lb. pressure. Use of short stacks, visible in Fig. 8, is made possible through the use of forced draft supplied by blowers driven by small steam-turbines. The blowers are just behind the burners, which are capable of operating on either gas or oil as fuel. Gas is being used as fuel at the present time, obtained from a nearby well.

Below the main floor are situated five small fuel oil tanks—two on one end of the barge and three on the other end—having a total capacity of 730 bbl. Fresh water is stored in a 3-compartment tank having a total capacity of 925 bbl. A tank serving as a hot well is situated beneath the feed-water heater and the two small utility pumps set between the boilers.

Superheated steam is delivered to the drilling barge through a main line constructed of 5-9/16-in. drill pipe and equipped with couplings that provide the flexibility required between the barges.

Laterals from the main steam header are kept at a minimum and these are all large-sized. In other words, thought was exercised to avoid small connections to the main header in random fashion merely to save piping.

Pressure-reducing valves are installed on lines supplying steam to the low-pressure equipment. Strainers are also installed on small lines but a strainer on the main line was purposely omitted because it was believed that the high velocities might cut-out the strainer and otherwise cause trouble.

The marine-type condenser on the drilling barge receives the exhaust steam and returns it to the boilers at a vacuum as high as 15 in. of Hg. A vertical steam pump set beneath the condenser pumps lake water through the condenser to effect the necessary condensing. A relief valve is installed to "bleed-off" trapped air from the condenser.

Valves and Piping

The piping layout of the entire barge is one of the most thorough jobs ever witnessed. Seamless tubing and drill pipe were used throughout. All joints are welded even including piping as small as ¼ in. On piping 2 in. and smaller, the new socket-type welding fittings were used throughout.

Every valve on the barge is flanked by either one or two unions to permit its being removed from the line for replacements. "Hammer" unions, i.e., unions having lugs that may be hammered to loosen or tighten them were used extensively. Incidentally, on the steam lines steel-to-steel ground joints were employed because of the effect of superheated steam on softer alloyed metals.

It has been mentioned that plug valves were used in many places but gate valves were used as well. In all possible instances, gate and check valves were selected that could be repaired by replacing parts without removal from the line.

General

Many have wondered whether it is necessary to dredge or otherwise prepare a "platform" to provide a level resting place for the barge. Work of this type is never required, partly because most lakes and bayous have fairly level bottoms and partly because the weight of the barge displaces the mud or muck usually present and automatically prepares its own level bed. Whenever the barge is found to list slightly, the list may be corrected by lightening one or more of the hull compartments as required—another important reason for adopting compartments in the design of the hull.

In calculating stability, the most severe condition pictured as a design basis includes 12,000 ft. of 9⅝-in. casing suspended in the hole and 14,000 ft. of 4½-in. drill pipe standing in the derrick. Wind load capacity is the same as used in A.P.I. specifications for derricks—70 mi. per hr.

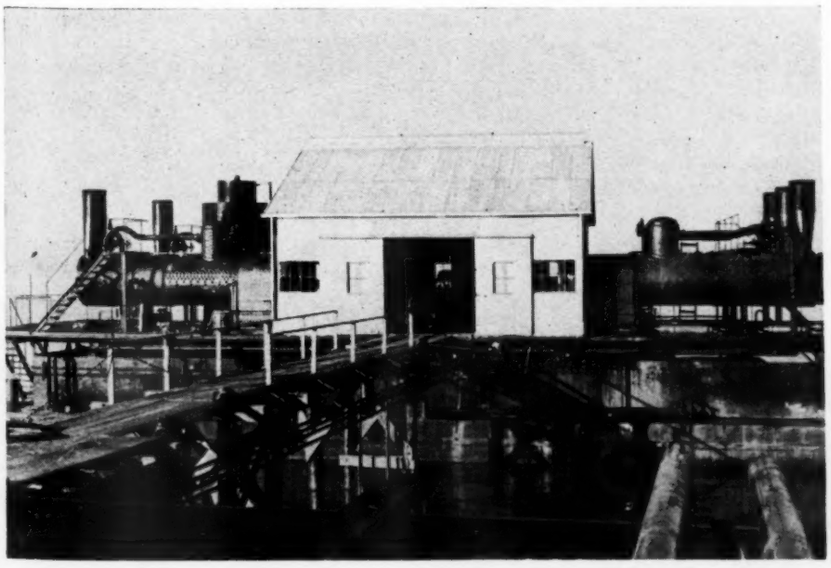


Fig. 8. Boiler barge and wooden walkway connecting to drilling barge

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The Technology of Refining Processes

Article 2

CATALYTIC CRACKING and REFORMING

By
ARCH L. FOSTER
The Lubri-Zol Corporation, Cleveland, Ohio

Introduction

CATALYSIS is the most intriguing field in all refining technology. Because its results are obvious, and its reactions and the mechanism are buried in the haze of things unknown, the catalyst becomes a veritable "Philosopher's Stone," far more potent and mystifying than any such stone dreamed of in the Middle Ages. For it makes possible, even simple, the manufacture of products either difficultly obtainable or impossible to obtain in commercial quantities at an economic price. The application of catalysis to refining has been termed everything from a fad of dupes to the answer to the refiners' prayers—with strong likelihood that it is much more deserving of the latter phrase.

Catalysis makes practicable the cracking of heavy oils, or the reforming of light distillates, under low temperature and low pressure conditions unheard of in thermal cracking. It converts heavy residual, low-priced oil "wastes" to materials of wide application in commerce and industry, either as motor and aviation fuels or as heavier distillate-type products — furnace oils, Diesel fuels, and gas oils for all purposes—through what the uninitiated may feel is the "magic" of its obscure reactions.

Unfortunately for the romantically minded, the magic does not exist, unless by "magic" we mean that which we cannot explain. Every result of the application of a catalyst to an industrial operation has been discovered by painstaking effort, often by cut-and-try methods, and the activities of different catalysts have already been widely cataloged. The only synonyms for magic here are hard work and good luck.

C. Catalytic Cracking

The definition of a catalyst has been variously stated. Probably as good a working definition as any simple statement could be is that a catalyst is any material that produces a reaction between two or more other materials that would not otherwise occur, and into the endproduct of which reaction the catalyst itself does not enter; or, a material that will produce a given reaction under much less severe conditions than are required to obtain that reaction in the absence of the catalyst; or a material that greatly hastens a reaction that proceeds at an extremely slow rate in the absence of the catalyst. Theoretically, therefore, any existing material *may* be used as a catalyst for one reaction or another.

ARCH L. FOSTER

is widely known in refining and automotive technical circles—His present work as sales engineer for The Lubri-Zol Corporation is concerned principally with lubricants and lubricant-treating methods — Previous experience since 1922, when he graduated from the University of Texas, was with the Gulf Refining Company, the U. S. Bureau of Mines, and the *National Petroleum News*.

In practice, a catalyst is usually a metal, a metal salt, or other chemical element or compound placed in contact with a material or mixture of materials to produce or to hasten a desired reaction. More recently auxiliary catalysts, called "promoters," have been used by researchers to strengthen the effect of primary catalysts and to improve their activity. Thus many catalysts become in effect complex mixtures; certain olefinic hydrocarbons can be reduced by the addition of hydrogen, in the presence of iron and copper oxides, or of metallic iron and copper oxide, whereas the addition reaction will not go to completion with copper oxide alone. The iron or iron oxide is referred to as a promoter, and Ipatieff (*Catalytic Reactions at High Pressures and Temperatures*, The Macmillan Company), conceives the idea that a complex is formed between the two oxides or metal and oxide that possesses catalytic effects not possessed by either alone.

One theory of catalytic action is that for some short interval of time the components involved may form a loose, unknown chemical combination with the catalyst and under these conditions are brought close enough to each other, chemically speaking, to themselves unite with each other, dissolving the temporary bond with the catalyst, which is released to carry on the same helpful aid to other reactants.

Catalysis has been used in the chemical industry and in various industrial processes for more than a generation, but was introduced into the refining industry about the time of the first World War or shortly before. Earlier, the use of a nickel catalyst as finely-divided nickel on an "inert" carrier was applied to the hydrogenation of cotton oil and other vegetable and animal oils, with the result that much of the cooking fat now used by the housewife comes from the cotton seed, after hydrogenation to a white, unctuous semi-solid.

The first really important application of a catalyst to petroleum refining was about 1912, when McAfee discovered that anhydrous aluminum chloride effects the destructive hydrogenation or cracking of heavy oils, such as gas oil, to produce gasoline low in sulphur and highly paraffinic. In fact, until the "octane race" began and anti-knock properties became of prime importance the aluminum chloride cracking process of Gulf Refining Company was a most successful one, technically speaking, and still is from that viewpoint, although the paraffinic, saturated char-

acter of the hydrocarbons produced yields a low octane number but very pure motor fuel. At one time the chlorine, made from sodium chloride solution by electrolytic methods, for the manufacture of the anhydrous chloride amounted to 15 or 20 tons per day, possibly more.

Recently Developed Catalytic Cracking Processes

In the early thirties E. J. Houdry came to this country from France with the essentials of a process for cracking heavy oils with the aid of metallic oxides and silicates. Shortly thereafter Dr. V. N. Ipatieff, the great Russian authority on catalysis who was conducting researches in this field before the turn of the century, came to America as a professor in a leading university and began study of the application of catalysis to petroleum refining. The petroleum industry was definitely committed about this time to a program of catalytic research.

The Houdry Process was developed first by Socony-Vacuum Oil Company and further developed later by Sun Oil Company, with the result that a pilot plant of a few hundred bbl. per day, constructed in 1933, has been expanded to a daily charging capacity of 150,000 to 200,000 bbl. in 1939. The work conducted by Ipatieff and his collaborators in Universal Oil Products Company has resulted in the construction of a large number of catalytic units for olefin polymerization, distributed throughout this country and abroad, and in catalytic cracking methods not yet disclosed in public print.

In the wake of these developments have come the allied processes of dehydrogenation and hydrogenation, of isomerization of light hydrocarbons, cyclization, alkylation of olefins with paraffins, aromatization of paraffinic and naphthenic compounds, catalytic refining and sulphurization; and there are doubtless many other methods to come. The field of catalysis in refining has been barely touched.

These various methods for building new, or rebuilding existing, hydrocarbons will be discussed in later articles. Catalytic cracking and reforming processes are for the time the most important developments in refining technology. The Houdry Process consists essentially in vaporizing the charging stock, gas oil, crude, or reduced crude by heating by exchange, pipestill, or other suitable means, and flashing in a tower, the vapors entering chambers or "cases" containing the catalyst, wherein the cracking reaction takes place, forming gasoline, small percentages of gaseous paraffinic and olefinic hydrocarbons, and depositing carbon as coke on the catalyst. At regular intervals the vapors are switched from one case to another—several cases are provided, connected to the charge vapor line in parallel—and heated air is introduced to the by-passed case to regenerate the catalyst by combustion of the coke; the products of combustion are swept out by inert gas such as flue gas, and the case is again ready to take its turn in the system.

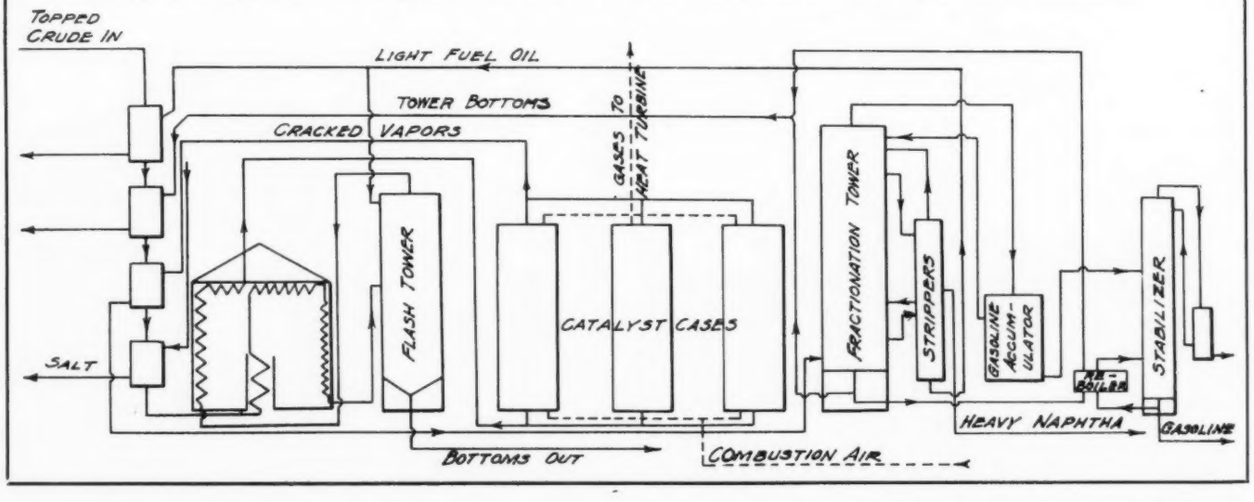
The Houdry Process may be operated to produce a maximum of gasoline on a once-through routine, with lesser amounts of gas oil suitable for thermal cracking operations, gas, and coke, which is consumed in regenerating the catalyst; or it may be operated to produce a maximum yield of gas oil for use as cracking stock or for sale as such, and a fair yield of gasoline, with incidental gas and coke production. It may also be used to produce an excellent blending naphtha for aviation fuel. These types of operation are current in different plants at present and their conditions and results will be discussed briefly. Units having a crude capacity as great as 25,000-30,000 bbl. per day are in operation.

Assume a reduced crude is processed; the virgin gasoline, kerosine, and possibly gas oil have been removed by heat exchange and flashing in a primary fractionating tower. The reduced crude is pumped through a pipestill and flashed in a vaporizer drum or column, and the heavy bottoms withdrawn to storage after exchanging heat with incoming raw crude oil. If the charge stock is gas oil or a similar distillate it will be completely vaporized in another flash tower and the entire vapor production sent to the catalyst cases. The temperature of the reduced crude when flashed may be 875-880°F. Vapors reach the catalyst cases at about 850-860°F. and 25-30-lb. gauge pressure, the cases being held at 900°F. by a stream of molten salts that controls uniformly the temperature of reaction. The catalyst is retained in trays or other supports in the case, the vapor coming into intimate contact with the catalyst, which is molded into bars, cylinders, disks, or other forms to permit easy passage of vapors through the mass. Cracked vapors pass to the fractionating tower from which endpoint gasoline is taken overhead, and stripped gas oil from the bottom.

The cycle on the catalyst cases may be varied widely, but a typical routine is ten minutes on stream, five minutes for removal of hydrocarbon vapors, ten minutes regeneration with heated air, and five minutes for removal of the air and combustion products by inert gas to prepare for the next cycle on stream. Thus two complete cycles per hour are maintained by this procedure.

The percentage of coke deposited and burned in regeneration varies from 3.5 to 6.5 percent, approximately, with 3

Fig. 1. Simplified flow diagram of Houdry catalytic cracking unit. Salt cooling system is not shown



to 7 percent dry gas. The remainder of the charge is recovered as liquid, either gasoline or gas oil. Gasoline yields reported vary from 33 percent when operating for large distillate fuel oil yields to about 50 percent when high gasoline yields are desired. Gas oil yields vary from 38 to 60 percent.

The gasoline produced by this process will show 77-81-octane number by the A.S.T.M. method and 7-10 numbers higher by the research method. Blending value of this gasoline is reported to be 90 or higher. A 20 percent blend having a 65-octane number gasoline showed 70.5-octane number, L-3 method. It is low in sulphur content, from 0.03 to 0.23 percent, depending upon the sulphur in the charge. Most of the sulphur in the charge is converted to hydrogen sulphide and is removed when treating the gases, as will be described in a later article. The gasoline is reported low in gum content, and after a caustic wash will pass the corrosion test but not the doctor test.

The catalyst used in this process for producing motor and aviation fuels is called a "hydrosilicate of alumina" described in a patent as composed of 76 percent SiO_2, 16.8 percent aluminum oxide, 1.6 percent ferric oxide, 2.4 percent calcium oxide, and 1.3 percent magnesium oxide. Catalyst composition may be varied depending on the purpose for which it is used. Catalyst life appears to be virtually indefinite; case design in the Magnolia unit at Beaumont, Texas, indicates that plans for discarding and replacing the catalyst involve long intervals.

In this Magnolia unit (*National Petroleum News*, Aug. 23, 1939, page R-346), the principal purpose was to produce a large yield of No. 2 fuel oil. Its operation is similar to that described above; topped crude is heated by exchange and parallel flow in an Alcorn pipestill to 825°F. and a 75-lb. outlet pressure, flashed in a tower at 40-lb. pressure with 8 percent of superheated steam. A temperature of 750°F. is maintained in tower overhead vapors. These vapors are superheated in a separate coil to 880°F., and sent to the catalyst cases for cracking at 900°F., then enter the fractionator at about 735°F.

This routine gave a gasoline yield of 33.3 percent of the total crude, or about 39 percent of the charge to the catalyst; 50 percent of light fuel oil and gas oil, 13 percent of tar bottoms —a residuum run—and only 4 percent gas and loss. The gasoline showed an L-3 octane number of 82.6 and a blending value of above 90 when blended with a paraffinic virgin naphtha of 65-octane number.

In addition to cracking crudes, reduced crudes, and heavy distillates to gasoline, gas oil, gas, and deposited coke, which is consumed in the regeneration cycle, the Houdry Processes also include catalytic viscosity-breaking to reduce viscosity of heavy residues to fuel oil specifications; catalytic treatment of gasolines from any cracking source and treatment of aviation gasoline to remove gums and sulphur; reduction of heavier oils to Diesel oil and furnace oil specifications; desulphurization of gases by catalysts, and catalytic polymerization of olefins as a first step in the preparation of isoparaffins such as isoöctane and homologues for aviation and motor fuel blending agents. These phases of the process will be discussed in turn under the discussion of polymerization, and the treatment of light distillates, in a later article.

Aviation gasoline is produced by the Houdry method, and several million gallons have been so made and used. When acid-treated, sweetened with doctor solution or other sweetening methods, which include catalytic sweetening, also developed as a part of the Houdry menage, and redistilled to endpoint requirements, this product passes aviation oxidation and gum tests and acid-heat requirements. The finished fuel rates 76-80, A.S.T.M. method, and is raised to 87-92 rating by the addition of 2 to 4 cu. cm. of lead. Blended for example with 25 percent isoöctane and 2¾ cu. cm. of lead this material yields aviation fuel of 100 Army Method octane number, a fuel greatly in demand in military aviation service, and requiring only about one-half as much isoöctane as does natural aviation fuel. Houdry motor gasoline is too low in vapor pressure as produced and requires addition of natural or refinery recovery gasoline to bring its vapor pressure to the 8- to 12-lb. required. Vapor pressures of 5.5 to 7.0 lb. are produced in this catalytic gasoline, satisfactory for aviation when cut to the desired boiling range.

To offset the lower temperatures and greatly lowered pressures used in catalytic cracking, we have the additional cost of catalyst, the greater pumping capacity, and the costs of auxiliary equipment to utilize the excess heat produced, especially in the burning of coke from the catalyst in regeneration. Lower temperatures mean less cost for fuel for the unit. Lower pressures mean lighter weights of metal in equipment. For example, in tubes up to 7-in. outside diameter, the tube wall in the Houdry unit is ⅜ in. Tube steel is either plain carbon, or alloys of 2 percent chromium, ½ percent molybdenum, at a price much lower than the 4-6 percent chromium, ½ percent molybdenum as used generally in thermal cracking with corrosive stocks. On the other hand, the average size of lines used in the catalytic unit is larger than for thermal cracking. The mixture of salts used to control case temperatures requires a main transfer line of 24-in. diameter in a 15,000-bbl. unit. Cost of the salt itself is not known to the writer but obviously the initial price represents a sizable sum, although the life of the salt should be virtually indefinite as leakage should be the only cause of loss. A million pounds of salt are used in the Magnolia unit. Cost of the "natural" catalyst for a 15,000-bbl. Houdry unit in 1938 was given as $36,000, or $2.40 per bbl. per day charge capacity. With a gasoline yield of 45 percent, this means a cost of $5.33 per bbl. per day gasoline output. The cost of catalyst for another 15,000-bbl. unit (Magnolia) making 39 percent yield on the charge with a minimum of light and medium distillate fuel oil is given as $18,000, half that for the earlier unit reported, the quantity of catalyst being omitted in both instances. Although these figures are relatively large in either case, the long life of the catalyst reduces the cost per bbl. of gasoline to a very low figure that cannot be estimated here because the exact life span is not known with certainty.

Additional equipment in the catalytic Houdry unit includes steam generating equipment wherein the hot salt from the catalyst cases passes in countercurrent exchange with water, a process that is said to return about 10,000 lb. of steam per hour to the refinery after supplying steam for the unit; a combustion case wherein the partially-burned gases from coke removal are burned completely to CO_2, the gases then passing to a "heat turbine" that powers an air compressor and an electric generator. The Houdry unit requires only 60 percent of the oil-pumping capacity required by a thermal unit of like size, but total pump capacity is nearly five times that of the thermal unit. Because of the lower temperatures and pressures the pumping capacity requires no more power than that needed for a thermal unit. In fact, the catalytic is reported to use no more power than the same thermal capacity, because of the lower pressures used; cost per unit of power or equipment capacity is correspondingly lower.

The salt system requires 11 pumps and 25 to 30 motor-actuated valves, most of them included in the cycle-timer automatic control system for switching back and forth during the cracking-sweep out-regeneration-sweep

out cycle twice or more per hour on each catalyst case. Condensers and coolers having 30 percent more surface are needed, and 80 percent more heat exchange capacity is used in the catalytic unit. The Magnolia unit cost $2,980,000, or nearly $200 per bbl. of daily capacity.

The turbine-air-compressor assembly is a unique unit in this country, developed in Switzerland by the Brown-Boveri Velox steam boiler interests but never before used in the United States so far as is known to the writer. Operating at 6000 r.p.m. it compresses all regenerating air for the cases and drives a 600-kw. synchronous generator at 1800 r.p.m. to utilize the excess heat of the catalyst case coke deposit.

As mentioned, two types of catalysts are employed in catalytic operations, the so-called "natural" type and the synthetic product. The natural catalyst is made from naturally-occurring ores or minerals, such as bauxite and other alumina-bearing materials, and may contain iron oxides, silica, and oxides of other heavy metallic elements. These materials are rugged when formed into cylinders, rods, or other shapes, and show a long activity life, a year of use resulting in no appreciable loss of effectiveness, although plants have been designed for catalyst discarding each six months.

The synthetic catalysts such as chromic and other metallic oxides are higher in cost than the natural type, but show higher efficiency than the latter. In certain types of operation these catalysts have shown little if any loss of efficiency after 1000 regenerations, which should reduce catalyst cost per barrel of product to a low figure corresponding possibly to that found for the cheaper natural catalyst. Recent estimates show that 5000 bbl. or more of gasoline may be produced per ton of catalyst, either natural or synthetic, which reduces the unit cost well below one cent per bbl. It must be kept in mind that present-day estimates are based on limited experience and must be considered as indicating the order of magnitude of costs rather than as exact values; exceptions to this are, of course, individual values that have been determined from an adequate length of experience in a few cases. As is indicated by the reported cost of catalyst for the two Houdry units discussed in print, the value of this item may be expected to be reduced very importantly as our experience and capacity of installations increase, as was the case with the costs of thermal cracking units.

Catalytic Reforming

Reforming low-grade gasolines and naphthas by catalytic methods offers to the small-to-medium-sized refiner the greatest chance for much-needed improvement of motor fuel and financial return on investment, in the opinion of virtually every qualified engineer who has ventured an opinion. The Houdry system also includes reforming, about the details of which little has been made public. Other reforming methods are those developed by the group of refiners represented by the M. W. Kellogg Company, using either natural or synthetic catalysts, chiefly the latter; and the Phillips Petroleum Company's process that employs a bauxite catalyst.

In the Phillips process low-octane number naphtha is reformed in 90-97 percent yields, increasing the octane rating from 8 to 25 numbers, the increase depending on the original rating of the charge and the yields obtained. Operating conditions are 950-975°F., and 30-lb. pressure, with charge flow-rates to about 500 bbl. per ton of catalyst per day. (*National Petroleum News*, Sept. 20, 1939, p.R-394.) Under this procedure, for example, a Rodessa naphtha was improved from 29 to 50 octane number with a 95 percent yield, reducing the amount of lead required from about 4 cu. cm. to 2 cu. cm. to bring its rating to 70 A.S.T.M., a saving of approximately 0.5 cent per gal. on lead.

In another instance a 60-octane number, 314°F. initial boiling point Coastal naphtha was raised to 72.5 octane rating without the use of lead, a saving of about 0.28 cent; the initial point was reduced to about 100°F., vapor pressure raised from 1.2 lb. to about 8 lb. and the refinery price increased by more than 0.5 cent per gal., a gross improvement of about 0.8 cent per gal. including the loss on a 95 percent yield.

Earlier catalytic cracking-reforming processes were batch type, that is so far as each catalyst case was concerned, and the catalyst was regenerated *in situ* after being disconnected from the cracking system. A continuous process has been developed wherein the vapors to be cracked and the catalyst are brought into contact continuously and countercurrently, the catalyst being also regenerated continuously outside the cracking zone. Synthetic catalysts are used, and yields are obtained as shown in Table 1.

TABLE 1.

Comparative yields and octane ratings, thermal and catalytic reforming.

Thermal Reforming		Catalytic Reforming	
Yield, percent	Octane number	Yield, percent	Octane number
68	84	78	84
68	84	85	80
60	88	76	88

With any given price placed on the reformed motor fuel, the total value of the catalytically-reformed product of the same octane number is 15 percent more than for the thermally-cracked product, because of higher yield. The product from catalytic reforming by this process is asserted to be essentially aromatic, though containing little if any benzene; it shows as high octane number for the heavy ends as for the lower-boiling constituents, endpoints to 450°F. giving satisfactory anti-knock rating relationships. The acid-heat values for this product make it satisfactory for aviation fuels; the high endpoints permissible improve yields and the economics of the process.

The cost of these continuous reforming units is said to be about 60 percent of that for corresponding catalytic units wherein the catalyst is regenerated in place. This, it is asserted, is due to the excessive cost of auxiliary regenerative equipment, which for the continuous unit is small in amount of equipment needed and thus in cost of installation. For the production of gasoline of approximately housebrand octane rating, that is 70-75, the economy of this catalytic system is reputedly comparable to that for thermal reforming.

The lowest capacity unit that is practicable has not been definitely determined, at least up to a recent date, but is known to be considerably smaller than for a catalytic cracking unit. It is understood that the experience gained by operation of a 1000-bbl. unit now under construction will doubtless shed much-needed light on this item. At present a 3000-bbl. unit is considered economical for the refiner who has that amount of low-grade virgin naphtha to reform daily.

Calculations based on assumptions that cannot at the time be verified by actual experiences are always venturesome. Costs of thermal cracking have been variously estimated at from 12-14 cents per bbl. to 17-20 cents by the modern combination unit, depending upon the bases for calculation. Once-through catalytic operations have been estimated to cost as much as 10-12 cents per bbl., with estimates as low as 3-5 cents in specific instances. The lower figures may more possibly apply to catalytic reforming.

A somewhat better idea may be obtained by calculating the additional value of products to show the margin of return from which the refiner may pay additional cost of catalytic crack-

ing. From figures given earlier in this article, a 20 percent blend of catalytically-cracked naphtha increases the octane rating of a 65-O.N. virgin gasoline to 70.4. A 30 percent blend brings this octane rating to 73 L-3 method, an increase of 8 numbers. Assuming that 1 cu. cm. of lead is required to effect the same increase, the extra value of this high octane number blending material is 0.26 cent per gal. of finished gasoline—that is, for 0.3 gal. of blending fluid, or 0.87 cent per gal. of catalytic product. Therefore, the refiner has this margin, 0.87 cent per gal., from which to pay additional cracking or reforming costs or from which to take a profit on his operations. For a 10,000-bbl. unit yielding 45 percent gasoline or 4500 bbl. (189,000 gal.) the operator has $1644.30 per day to cover extra cracking costs.

A theoretical comparison of returns from thermal and catalytic cracking or reforming may be made by assuming for convenience a 50 percent gasoline yield, 40 percent gas oil, and 10 percent gas and loss from catalytic operations; a 65 percent yield of gasoline, 25 percent heavy fuel oil, and 10 percent gas and loss from thermal cracking. Assuming further, 72-octane number for thermal gasoline having 80-octane number blending value, and 80-octane number having 90-blending value for the catalytically-produced gasoline. If the blending value of the thermally-cracked material assumed is equal to one cu. cm. of lead in raising the rating of virgin naphtha of, say, 65 O.N. to 73 rating in a 30 percent blend, or 0.87 cent per gal., then the value of the catalytic product will be 25/15 of that value, or 1.45 cents per gal. of blended gasoline. If the virgin material is valued at 5 cents F.O.B. the refinery, the thermally-cracked material is worth 5.87 cents, and the catalytic product 6.45 cents to the refiner. Present market values for gas oil and heavy fuel oil are given in Table 2, and gas and loss are disregarded for calculation purposes, being equal by assumption. The comparative market values for 100 gal. of crude oil converted to these products as assumed may be calculated as shown in the table.

TABLE 2.

Market values of thermally- and catalytically-cracked reduced crude oil, per 100 gal.

Thermal			Catalytic		
Product	Price, cents per gal.	Value	Product	Price, cents per gal.	Value
65 gal. gasoline	5.87	$3.82	50 gal. gasoline	6.45	$3.23
Gas oil	.....	.....	40 gal. gas oil	3.25	1.30
24 gal. fuel oil	1.07	0.26	Fuel oil	.....	.....
Total value		$4.08	Total value		4.53

Therefore, by this calculation the value of the topped crude in finished products is 45 cents more per 100 gal. when catalytically cracked than when thermally cracked to maximum gasoline yield. Any other assumption of yields and values will of course give a different relationship in values.

In the last analysis no generalized calculations can answer the refiner's question as to whether or not catalytic cracking or reforming will pay in his individual situation. The answer can be arrived at closely if competent engineers make the detailed calculations based on current prices and the refiner's individual situation, taking into account all the variables that have not been considered here and which vary widely from plant to plant. The final answer at any given time is obtained in the original way—by construction and operation of a unit and determination from the resulting returns if the unit is paying its way—an expensive but conclusive experiment.

EDITOR'S NOTE: The next article in this series will take up the absorbing subject of polymerization, alkylation, and correlated new developments in refinery processing.

P 532.2

Central Steam Equipment Used to Remove Paraffin from Tubing in West Texas

AMONG other problems confronting operators in West Texas, paraffin takes its place as one that has caused as much trouble and occasioned as much time and expense as any other single element. Not limited to manifesting itself only during winter months when lower temperatures prevail, as in some areas, paraffin deposition in tubing and flow lines is more or less a year-round occurrence in West Texas.

The accompanying photograph shows the control-head used by one company to inject steam into lengths of tubing to remove paraffin. Tubing is pulled from a well and hauled by truck to the production camp, at which the steaming equipment is situated.

In front of the control head is a pipe rack on which the tubing may be laid with the collared ends on the control-head side. Each length is rolled into place before the control head and the yoke shown is engaged around the pipe and behind the collar as a means of forcing the open end of the tubing against the packing around the steam inlet. Movement of the yoke is controlled by a foot lever shown at the lower edge of the picture.

Steam is admitted to the tubing slowly to heat the paraffin throughout the length of the joint. If proper care is exercised, the entire "string" of paraffin may be blown easily from the tubing after it has been softened throughout its length. Too rapid heating of the paraffin adjacent to the inlet will only cause the paraffin to become clogged.

An oil-field boiler set just behind the control head supplies steam for the operation.

It has been found that tubing strings can be pulled from the well, hauled to the camp and cleaned, and then hauled back to the well more quickly and economically than any other method devised to combat aggravated paraffin depositions.

Control-head designed to admit steam to tubing joints

P 447.
P 533.2

Night view of well on fire

By
WALLACE A.
SAWDON
Pacific Coast and
Foreign Editor

Dual Purpose Well Salvaged For Repressuring After Blowout and Fire

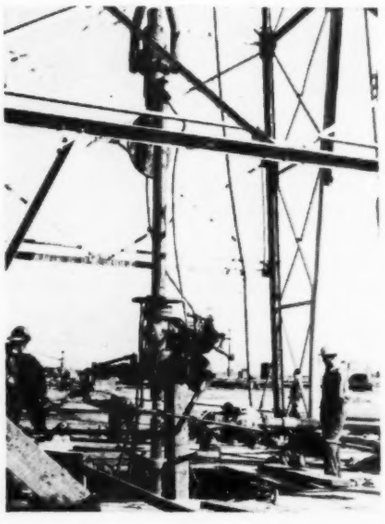
Blowout and resulting fire brought under control by capping well with specially designed manifold—gas from upper sand to be used to repressure lower oil sand in same well

INTERRUPTING its completion as a key input well utilizing gas from an upper sand for repressuring, a blowout and fire required quick action and ingenuity in recovering control of Ohio Oil Company's A. S. Gough No. 12 well in the El Segundo field, California. The well was originally an oil producer but was being converted to a gas input well with gas taken from an upper zone when it broke loose and caught fire shortly after noon on Saturday, January 13, 1940. The fire was extinguished by steam on the following Monday morning and the well placed completely under control in a little less than a week after it blew out.

The well was completed as an oil well in June, 1938, having an initial production of approximately 200 bbl. per day on gas lift. A 6⅝-in. water string had been cemented at the top of the sand at 7343 ft. and a 5-in. liner set through the sand to 7411 ft. Production recently declined to such a point that it was decided to utilize the gas from an upper sand for repressuring the oil zone employing the same well for the dual purpose.

Without pulling the 5-in. liner, the 6⅝-in. casing was perforated between the depths of 3825 ft. to 3840 ft. A string of tubing was then run to a depth of approximately 7300 ft. and packed-off in the casing at a depth of 3844 ft., as shown in Fig. 1. A pack-off tubinghead was installed on the upper end of the 6⅝-in., which had been run through an 11¾-in. surface string. Gas passing through the perforations was carried to the surface in the annular space between the tubing and casing, taken off through a side outlet, and returned to the oil sand through the tubing.

Pressure at the tubinghead was 1450 lb. per sq. in. Provisions for obtaining gas at lower pressure for lease use were made by installing one 1400 lb. to 250 lb. regulator and one 250 lb. to 230 lb. regulator. It was found that the oil sand would take but little gas at the natural flow pressure and plans were being made to install a compressor to build the pressure to 3000 lb. when the well blew out and caught fire.



With the blow-off control manifold assembly still in place, a new derrick has been erected and work begun on repairing the well

As in virtually all blowouts of this nature, the exact cause can never be definitely determined. The high-pressure regulator valve may have become stuck or a slight leak may have caused it to freeze. After the blowout, the gas blew a large amount of sharp, abrasive sand, and sparks caused by its striking against steel probably ignited the gas. The sand soon cut away the fittings and within 48 hours let the tubing drop. The casinghead then cut-out and let the gas into the 11¾-in. surface string. The full flow through the 6⅝-in. casing was estimated at between 50 and 60 million cu. ft. per day.

Three 100-hp. boilers were quickly moved-in as a source of live steam to be used in fighting the fire. Although little time was lost in successfully extinguishing the blaze, the derrick was destroyed by the heat. As soon as things cooled-off the debris was cleared

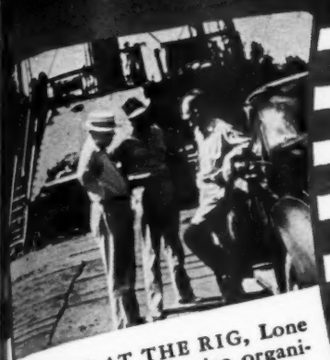
CEMENTS FOR OIL INDUSTRY SERVICE

—BACKED BY

CONTINUING RESEARCH

IN THE

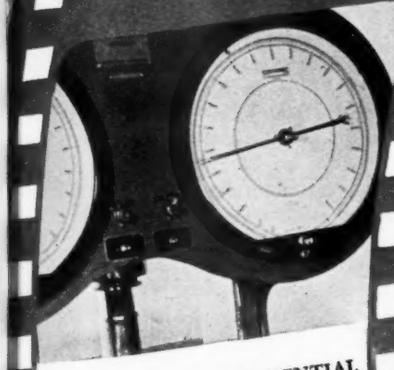
FIELD AND LABORATORY



RIGHT AT THE RIG, Lone Star's oil-field service organization studies cementing problems—to keep the men at the mill constantly informed on oil-field requirements.

TESTS FOR NEEDED PROPERTIES and qualities—such as length and ease of pumpability at high temperatures—are part of daily routine.

NEAT-CEMENT TEST SPECIMENS are cured at 140, 170 and 200° F., to approximate the various conditions encountered in oil-well service—



AND STRENGTH, SO ESSENTIAL in oil-well cementing, is constantly checked Work like this goes on all the time—we call it "keeping pace with progress."

Day in and day out, Lone Star's oil-field organization studies cementing problems right at the rig, to keep an accurate line on the Oil Man's requirements. Close contact with problems in the field enables us to make cements with the properties and qualities needed to meet changing conditions of oil-industry service.

That is why 'Starcor' and 'Incor' deserve to be called the Oil Man's Cements—because they are made to measure for today's oil-industry needs. Use 'Starcor' for deep wells, greater length and ease of pumpability at high temperatures. Use 'Incor' for wells of moderate depth—earlier drill-out, wells on production quicker. Insist on 'Starcor'* or 'Incor'*—it'll pay you well. *Reg. U. S. Pat. Off.

LONE STAR
CEMENT CORPORATION

DALLAS: Santa Fe Building . . . . HOUSTON: Shell Building

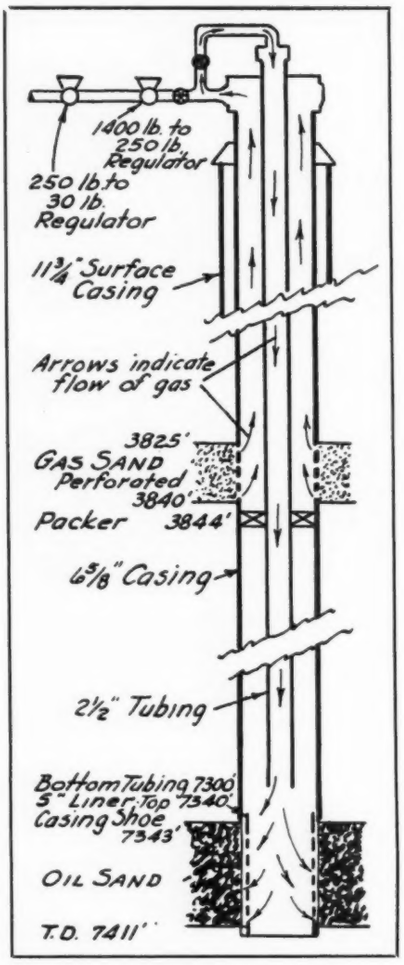


Fig. 1. Sketch of well equipped for repressuring

Specifications and Description of Material as Follows:

A: Swivel guide plate 2-in. thick by 16-in. center, 7¼-in. bore with one 2-in. hole.

B: Stack 10-ft. long made of 7-in. O.D. 28-lb. Grade D casing.

C: Swivel tie-down plate 2-in. thick, 26-in. diameter, 7¼-in. bore with four 2-in. holes on 22-in. circle.

D: 7 1/16-in. bore 6000-lb. test double-flange type pressure-operated master gate valve with 6-in. Series 900 A.P.I. flanges.

E: 6-in. by 2-in. special mud cross with 6-in. Series 900 A.P.I. top flange and 4½-in. O.D. 10-thread female bottom connection with two 2-in. Series 1500 A.P.I. flanged outlets equipped with 2-in. flanged plug valves and one 2-in. adjustable flow bean assembly tested to 3000 lb.

One 6⅛-in. O. D. 26-lb. by 4½-in. O.D. 16.60-lb. 10-thread special packer, described as follows:

F: High-pressure stuffing box and gland assembly to effect seal between mandrel and outer sleeve.

G: Turning device with handle for rotation and setting of packer. This is constructed as follows: made of forged-steel ring, 12-in. diameter, 6-in. wide with bore to fit the 5 9/16-in. O.D. outer sleeve with two 2-in. solid bar handles, 2-ft. long, welded securely to the forged ring and to the outer sleeve.

H: The main part of the packer consists of a mandrel 20-ft. long overall made of 4½-in. O.D. 16.60-lb. Grade D drill pipe; and outer collapsing sleeve made of 5 9/16-in. O.D. 22.20-lb. Grade D drill pipe, the outer sleeve and the mandrel threaded to engage each other with 5-thread left-hand washer being installed between the bottom of the outer jacket and top packer sleeve. The packer proper consists of three 5½-in. O.D. neoprene rings securely wired to the mandrel and held in place by counter-bored thimbles.

I: 4½-in. O.D. by 18-in. overall 16.60-lb. special bluntnose guide equipped with four openings as indicated on drawing.

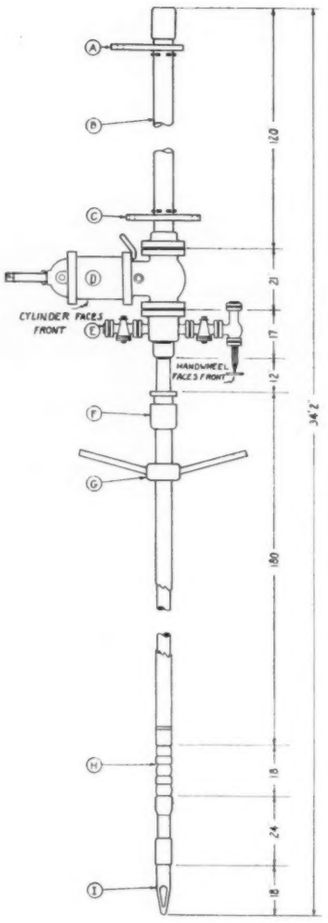


Fig. 2. Blowout control manifold assembly

away and an inspection made. It was first decided to make a flange connection by removing the top flange of the casinghead and installing an assembly consisting of a flange to match the casinghead flange, a 6-in. by 2-in. cross, a 6-in. 6000-lb. valve and a 7-in. stack to facilitate control. Before this could be built, however, the flange and packing of the casinghead had been cut away by the sand. A 6⅝-in. by 4½-in. packer was substituted for the flange but the high pressure prevented setting the packer in the casing.

A 10-in. stack was then temporarily placed over the well to prevent further cutting of the casinghead and landing base until a new packer could be obtained. Three more attempts to set packers failed because of the pressure and cutting action so it was decided to design and build special equipment for the job. This consisted of the blowout control manifold assembly shown in Fig. 2. The special packer, made without slips, has a mandrel consisting of a joint of 4½-in. drill pipe and an outer collapsing sleeve made of 5-9/16-in. drill pipe as indicated in the drawing. The annular space between these was filled with grease. A stuffing-box was used on the top of the 5-9/16-in. to seal to the 4½-in. mandrel.

The outside diameter of the packer was only 5½ in., so that ample clearance was provided in the 6⅝-in. casing. The rubbers were securely tied to prevent their blowing out. The assembly was rigged-up and the packer snubbed-in on Friday afternoon with very little trouble. After the assembly was tied down securely, the pressure-operated 6-in. valve was closed with 1500-lb. pump pressure and the well shut in. Following this, 480 bbl. of mud weighing 80 lb. per cu. ft. was pumped into the well, the entrapped gas being periodically blown-off.

Work of repairing the well and recompleting it to utilize the upper gas for repressuring the oil zone below began immediately, including erection of a new derrick. It is planned to go in with a pack-off spear, re-land and pack-off the 6⅝-in. casing on a landing head. After the tubing has been fished out through control gates, the well will again be equipped for repressuring. The gas is dry and is expected to remain so for a long time. It is believed that after the gas has been boosted into the oil sand at whatever pressure may be necessary it will continue its flow into the sand at a pressure of approximately 500 lb. per sq. in.

Practical Application of Electrolysis Prevention on Pipe Lines and in Compressor Stations

Part 2

By PAUL F. MARX
Engineer, Northern Natural Gas Company

A biographical sketch and photograph of the author can be found on page 48 of the January issue of *The Petroleum Engineer*, in connection with Part 1 of this article.

Insulating Ignition Systems

As mentioned previously, a serious electrolysis condition exists in compressor stations that use battery ignition systems. If not already found, investigation will show corrosion on piping within a plant. The fundamental cause of the existing electrolysis condition is that in virtually all cases the negative side of the primary ignition system is grounded. In so doing, the currents flow to the ground and cause electrolysis as they return to the source of supply. To determine whether or not such a condition exists, a d-c. voltmeter may be used for testing. The positive lead of the voltmeter is connected to any positive point on the primary side of the ignition circuit and the negative side of the voltmeter to "ground", such as an engine frame or building wall. If the meter registers, this will indicate that there is a negative ground somewhere in the circuit. Likewise, if the positive lead of the voltmeter is connected to any point on the negative side of the ignition system, a meter registration will show a positive ground exists. If there is a good ground any place in the circuit, full battery voltage will result. To correct this condition on a gas compressor that has its interrupter box mounted at the front end of the engine and is tripped by a roller connected to the camshaft, this steel roller should be replaced with a roller made of insulating material, such as canvas-impregnated bakelite, and the interrupter box should be properly insulated from the camshaft. A new negative lead wire must be strung between the interrupter case and the negative side of the battery so that there are no ground points within the primary circuit. The ignition coils should be investigated. There should be no connection between the primary and secondary windings. If such a condition exists, the primary currents will find a path through the secondary circuit and through the ground, defeating the "self-containing" purpose of the primary circuit. On all compressors where the interrupter is mounted on the side of the engine and is tripped by a metal finger placed in the camshaft, the finger should be replaced by one made of an insulating material and the interrupter insulated from the engine frame and, as before, the negative return taken from the interrupter to the battery.

After correcting such a ground condition, an indicating system for "grounds" can be mounted on the

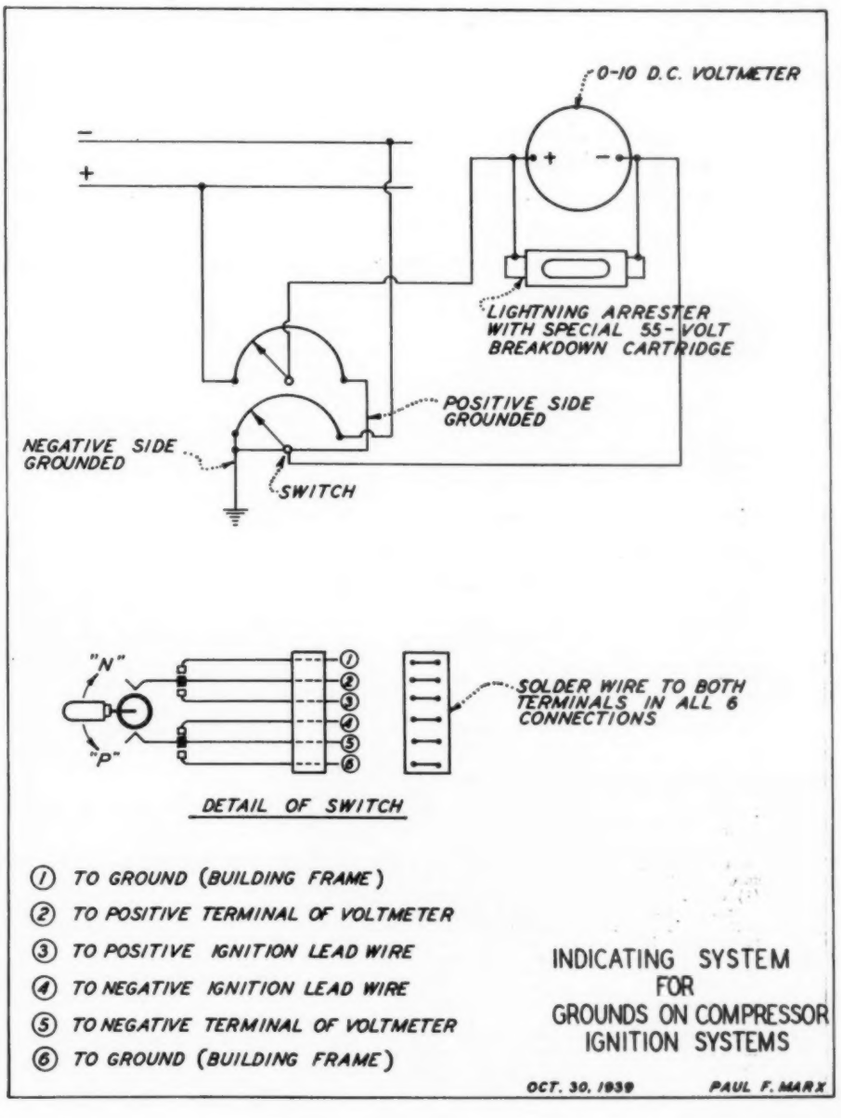


Fig. 9

Fig. 10—Tool for obtaining samples of sub-soil

FIELD INSPECTION SHEET — GENERAL DATA

Date _____ Test Hole No. _____ P.L. Mile No. _____ Pipe Line Name _____ Mechain Fig. _____
State _____ County _____ Sec. _____ (Twp)(Blk) _____ (Rge)(Sur) _____ Twp. Plat Bk. No. _____
Contractor Laying Line _____ Date Laid _____
PIPE DATA:-Kind _____ Size _____ Weight _____ #/Ft. Wall Thickness _____ Inches
Type of Welding _____ Type of Coupling _____ Type of Coating _____ Type of Wrapping _____
Length of line uncovered _____ ft. Area of pipe inspected _____ sq.ft. Inspected by _____

SOIL
Kind: Peat ○ Rocky ○ Cinders ○ Sand ○ Silt ○ Loam ○ Clay ○
Vegetation: Wooded ○ Pasture ○ Cultivated ○
Topography: General — Flat ○ Rolling ○ Rough ○ — Immediate — High ○ Low ○ Level ○
Drainage: Good ○ Fair ○ Poor ○
*Backfill: Hold ○ Loose ○ Settling ○
Depth of Cover _____ ft.
Resistivity in Ohms: As Found _____ Avg. _____ Saturated _____ Avg. _____
Moisture Content _____ %
TEST PLATE
Size _____ in. by _____ in.
Location from (Weld) (Coupling) (Upstream) (Downstream) _____ ft
(North) (South) of Line _____ in.
(East) (West) of Line _____ in.

CONDITION OF WRAPPING
Conformity: Conforming ○ Wrinkled A ○ Distorted A ○ Bulged ○ Sagged ○
Continuity: Continuous ○ Discontinuous A ○ Undetermined ○ Split ○ Torn ○ Crushed ○ Punctured ○ Tool Abrasion ○
Physical Condition: Normal ○ Abnormal ○ Pitted ○ Discolored ○ Adhesion of Soil ○ Soil Stress ○ Poor Application ○
WELDING CORROSION: *Girth ○ *Longitudinal ○
COUPLING DATA: Bonded ○ Unbonded ○
Notes:

CONDITION OF COATING
Thickness in Inches: Max. Min. Avg.
Penetration: None ○ Surface Only A ○ Partly Thru A ○ Punctured B ○
Continuity: Continuous ○ Discontinuous A ○ Undetermined ○ Holiday ○ Ruptured bubble ○ Inclusion ○ Root Puncture ○ Spalled Area ○ Crack ○ *Soil Stress ○ Soil Penetration ○ Tool Abrasion ○ New Tool Abrasion ○
Cracking or Checking: None ○ Checking A ○ Crack Partly Thru L ○ Crack completely Thru L ○
Physical Condition: Normal ○ Abnormal ○ *Completely gone ○ *Embrittled ○ Discolored ○ Disintegrated ○ Very pliable ○ Poor application ○
Bond: Good ○ Fair ○ Poor ○

CONDITION OF PIPE
Definite Surface Rust A ○ B ○
Shallow Metal Attack B ○
Pitted B ○
Depth of Deepest Pit _____ Mils
Penetration _____ %
Pitting when B= 3
Avg. Pit Depth _____ Mils
No. of Pits _____ /sq.ft.
COPPER SULPHATE ELECTRODE DATA
Zero Soil Pot. ⊕①②③④⑤⊖ _____ V.
Pipe-Soil Pot. ⊕①②③④⑤⊖ _____ V.
Ast. Pipe Pot. ⊕①②③④⑤⊖ _____ V.
Zero Soil Pot. ⊕①②③④⑤⊖ _____ V.
Pipe-Soil Pot. ⊕①②③④⑤⊖ _____ V.
Ast. Pipe Pot. ⊕①②③④⑤⊖ _____ V.
SOIL CORROSIVITY DATA
R_{sp} @ 500#/sq. in. _____ ohms/cm³
C @ 5 Min. _____ milli-amps.
R_{sp} > .8 ○ < .8 ○
pH Value
Time to Theo. 1st leak _____ yrs.
NOTES

Fig. 11—Detailed data sheet for pipe line surveys

motor-generator set panel board. If a 6-volt ignition system is used, a 10-volt d-c. meter is sufficient. If a 12-volt ignition system is used, a 15-volt d-c. meter should be used.

In Fig. 9 the wiring diagram of the above layout is given. When the operator moves the lever key to the "N" position and the meter gives an indication, this will show that a negative ground has occurred. Likewise, if a positive ground occurs, the meter will give an indication when the lever key is in the "P" position, so that it is a

DEFINITIONS OF TERMS USED IN FIELD INSPECTION SHEETS

1. **Actual soil potential:** The actual potential from pipe to ground. Obtained by subtracting the zero soil potential from the pipe-soil potential.
2. **Alligatoring:** Superficial surface roughening of coating, forming slight ridges in a fish- or alligator-scale effect caused usually by exposure of coating to sun before being laid; also, a mild pulling or distortion due to the separation of the protective whitewash covering.
3. **Bulged or sagged:** Does not otherwise conform to the normal shape of the protection material.
4. **Causation potential:** The potential causing corrosion (E_c).
5. **Checking:** (See cracks.)
6. **Conformity:** Conforms to the material beneath, and is neither wrinkled, bulged, sagged, nor distorted.
7. **Conductivity:** Conductivity is measured by the quantity of electricity transferred across unit area, per unit potential gradient per unit time.
8. **Corrosion:** Now generally used as a gradual wearing away by a chemical process.
9. **Corrosivity "C":** The potential corrosivity "C", a term used as a basis of classifying the degree of corrosion.
10. **Cracks:** Sharp-edged linear openings extending through the material.
11. **Decomposition:** Counter-electromotive force or polarization potential, (E_d).
12. **Definite surface rust:** An unmistakable accumulation of corrosion products has occurred since the coating was applied (1) which may be scraped in appreciable quantities from the pipe surface with a knife blade and (2) under which the roughening, if any, shall not have progressed to such an extent that the point of a knife will catch in the edges. The definition specifically excludes stains or mere discolorations on the surface of the pipe.
13. **Discontinuity:** One or more areas of underlying coating material or pipe exposed.
14. **Distorted:** Irregular depressions.
15. **Holiday:** Uncoated area usually less than the size of a small pea.
16. **Honeycombing:** A porous coating condition consisting of a mass having a cellular structure.
17. **Hydrogen equivalent:** The hydrogen equivalent of a substance is the number of replaceable hydrogen atoms in one molecule, or the number of atoms of hydrogen with which one molecule could react.
18. **Hydrogen ion concentration (See pH value):** The gram-ionic hydrogen equivalent per liter.
19. **Inclusion:** Kettle sediment and/or foreign material not normally included in the manufacturing of good coating.
20. **Ion:** One of the small electrified particles into which the molecules of a substance are broken up under the action of an electric current. It consists of one of the atoms and carries a unit charge of electricity. Those which are positively electrified are called "cations," and the negative ions are called "anions".
21. **Mil:** A unit of measure equal to one one-thousandth of an inch (.001 in.).
22. **New tool abrasion:** Resulting from uncovering the pipe.
23. **Ohm:** Resistance of a circuit in which a potential difference of one volt produces a current of one amp.
24. **Partly through:** Penetrating to a depth greater than 10 percent of coating thickness, but not punctured.
25. **pH value (potential hydrogen):** The logarithm of the reciprocal of the hydrogen-ion concentration.

$$pH = \frac{1}{(H^+)}$$

26. **Pinhole:** A slight puncture in the coating of a size implied by its name and which may or may not go through to the pipe.
27. **Pipe-soil potential:** The potential between a copper sulphate electrode in the ground and an electrode on the pipe.
28. **Pitted:** Where the metal attack has been measured and found to be ten mils (.010 in.) in depth or greater. The limit of error, even with careful measurement, may be as high as two mils. This tolerance is stated as an integral part of this definition.
29. **Punctured:** Where penetration has progressed to surface of underlying reinforcement or pipe surface.
30. **Resistivity:** The reciprocal of conductivity, and is measured by the resistance of a body of the substance of unit cross-section and of unit length at zero degrees centrigrade.
31. **Shallow metal attack:** Where the **definite surface rusting** has progressed to the point of definitely roughening the pipe surface. This shall be determined by scraping the rusted surface with a knife blade. The roughening can be detected by the knife blade catching in the etched or corroded surfaces.
32. **Soil penetration:** Where soil has embedded itself in the coating.
33. **Soil stress:** Excessive distortion due to soil "pull".
34. **Spalled area:** Chipped or peeled area.
35. **Specific resistance:** The resistance of a unit mass of soil, namely, a cubic centimeter after pressuring to 500 lb./sq. in. (R_{sp}).
36. **Surface only:** Not to exceed (in depth) 10 percent of the thickness of the coating.
37. **Wrinkled:** Small corrugations and/or folds.
38. **Zero soil potential:** The potential reading obtained in the soil when using a copper sulphate electrode and a ground rod.

NOTE: Coating conditions defined under items 2, 16, and 26 will presumably be seldom encountered and if found are to be included under **NOTES** on field inspection sheet.

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THE name SILVERLINE on a Working Barrel is recognized as a warranty of *long service-life* and *economical production.* The bulk of the ever-expanding orders for SILVERLINE Barrels are *repeat orders* from satisfied users.

To extend this high standard of performance, "Oilwell" now manufactures SILVERLINE Insert Pumps. They are available in both stationary-barrel and traveling-tube types in a wide range of sizes. Complete interchangeability permits many combinations of A.P.I. parts to suit well conditions. Two popular combinations of parts are illustrated for each type pump.

The following are some of the optional parts:

* ***Plunger, with or without top or bottom extension***
* ***Cup-type traveling valve***
* ***Combination traveling valve***
* ***Gas valve***
* ***Top or bottom seating assemblies***

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B Stationary-barrel Insert Pump with Bottom Seating Assembly and Plunger (without top or bottom extension).
C Traveling-tube Insert Pump with Combination Valve.
D Traveling-tube Insert Pump with Plunger (without top or bottom extension).

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INSTRUCTIONS IN USE OF FIELD INSPECTION SHEETS

Fill in all blanks.

Use red check (√) after descriptive item applying. If any descriptive item does not apply, indicate by a black cross (X). Uncertainty as to any observation shall be indicated by a dash (—).

The asterisk * denotes that the observation should be described in footnote if of interest.

When a preference of two items appears in parentheses, such as (North) (South), etc., cross out the item not applying.

If two kinds of soil apply, mark with numerals (1) and (2) giving preference to the latter, i. e., sandy clay should be indicated sand (1) clay (2).

When inspecting couplings, the indications found should appear in the space below "Coupling Data."

If a test plate, which is a piece of pipe cut from the same kind of pipe that is in the line at that particular test station, is placed in the ground, its size and location shall be filled-in under "Test Plate Data."

The depth of the pits shall be measured with a pit gauge. The recording should be in mils, i. e., a pit 0.025 in. deep should be recorded 25 mils.

When the numerical classification of "N" is (3) for "Pitted" under "Condition of Pipe", the average pit depth and number of pits per sq. ft. should appear in the spaces designated.

Severe pitting should be transferred to a piece of paper, sufficiently labeled, and the pit depths indicated in each area shown. This sheet to be attached to its corresponding Field Inspection Sheet.

The location of test holes and their numbers shall be placed on the Corrosion Data Sheets at their respective positions.

NUMERICAL CLASSIFICATION TO BE PLACED AFTER N, L, AND A

N	L	A
Avg. No. per sq. ft.	Avg. total length per sq. ft.	Avg. area per sq. ft.
1. 1 or less.	1 in. or less.	10 sq. in. or less.
2. Greater than 1 but not greater than 3.	Greater than 1 in. but not greater than 5 in.	Greater than 10 sq. in. but not greater than 50 sq. in.
3. Greater than 3.	Greater than 5 in.	Greater than 50 sq. in.

FIELD INSPECTION SHEET — GENERAL DATA

Date_____Test Hole No._____P.L. Mile No._____Pipe Line Name_____Sechain Fig._____
State_____County_____Sec._____(Twp)(Blk)_____(Rge)(Sur)_____Div____Dist____Twp Pl Sheet_____
Contractor Laying Line_____Date Laid_____
PIPE DATA: - Kind_____Size_____Weight_____#/Ft.Wall Thickness_____inches.
Type of Welding_____Type Coupling_____Type Coating_____Type Wrapper_____
Length of Line Uncovered_____ft. Area of Pipe Inspected_____sq.ft. Inspected by_____

SOIL

Kind
- Peat ○
- Rocky ○
- Cinders ○
- Sand ○
- Silt ○
- Loam ○
- Clay ○

Vegetation
- Wooded ○
- Pasture ○
- Cultivated ○

Back Fill
- Solid ○
- Loose ○
- Settling ○

TOPOGRAPHY

General
- Flat ○
- Rolling ○
- Rough ○

Immediate
- High ○
- Low ○
- Level ○

Drainage
- Good ○
- Poor ○
- Fair ○

CONDITION OF COATING

Thickness in Inches

Max.___Min.___Ave.___

Penetration
- None ○
- Surface Only ○
- Partly Through ○
- Punctured ○

Physical Condition
- Good ○
- Fair ○
- Poor ○
- Completely Gone ○
- Tool Abrasion ○

Bond
- Good ○
- Fair ○
- Poor ○

CONDITION OF PIPE
- No Rust ○
- Surface Rust ○
- Shallow Metal Attack ○
- Pitted
- Depth of Deepest Pit_____mils
- Average Pit Depth_____mils
- Number of Pits/sq.ft._____

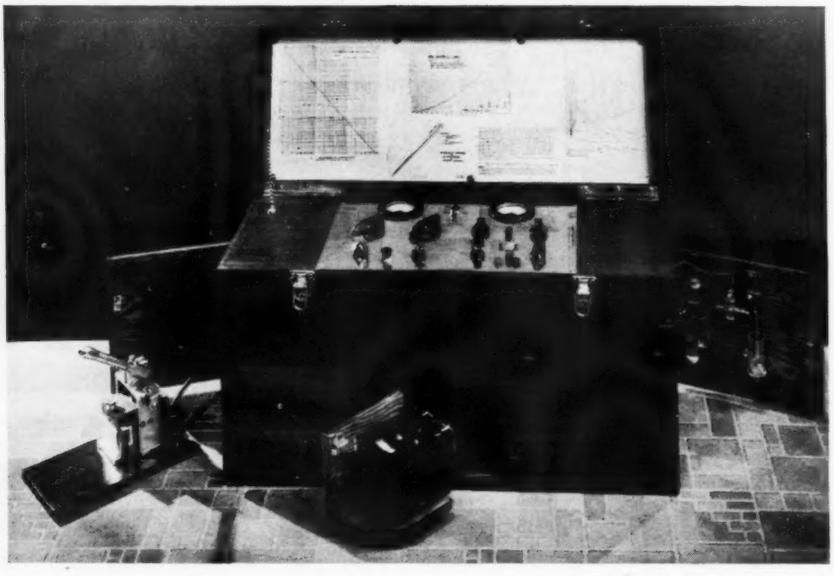
FAILURE OF LINE
- Corrosion Leak ○
- Pinhole in Weld ○
- Split Seam ○
- Dresser Rubber ○

Notes:

INSTRUCTIONS: Send in completed sheet for each hell hole dug.
Fill in data below heading wherever possible.
Put check mark in circle when any item applies.
Write any items of interest under "Notes."

Fig. 12—Modified data sheet for pipe line surveys

Fig. 13—Instrument devised for testing soil conditions



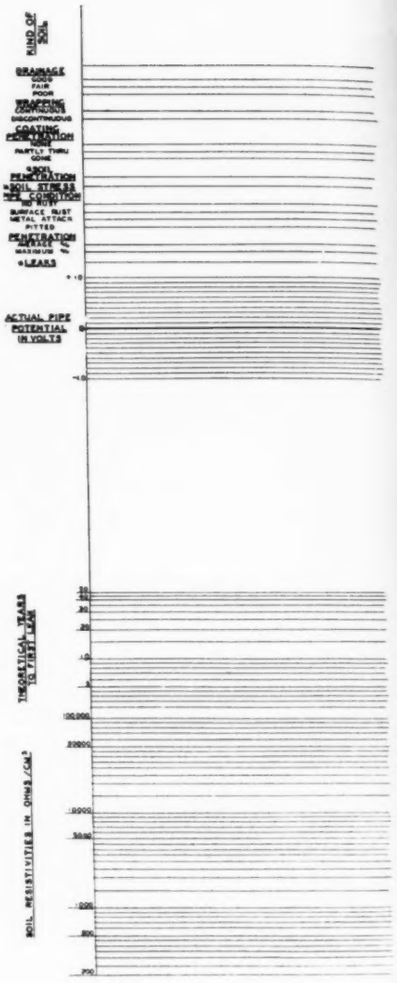


Fig. 14—Portion of master sheet used in correlating data

simple matter to retain a good check on the system. The higher the meter reads, the better the ground will be. The arrester is used to protect the meter so that any time a short occurs in an ignition coil, the 15,000 volts of the secondary when shorted through the primary will not ruin the meter. The impedance of the meter will hold the surge long enough for the arrester to "break."

Another possible source of electrolysis is from the d-c. exciters on a-c. generating units. Grounds emanating from this source are infrequent.

In the inspection of lines for electrolysis in compressor stations, special attention should be given to the smaller ones as these will be corroded more severely than the larger, as the amount of metal in these lines is considerably less, and damaging currents consequently have much more effect.

Soil and Inspection Surveys

Many companies are making extensive soil survey studies along their pipe

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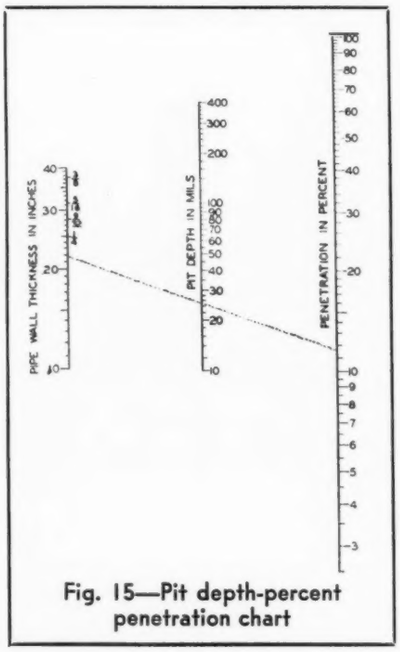


Fig. 15—Pit depth-percent penetration chart

lines. Briefly, one method of making such a survey is as follows: Soil samples taken at pipe depth with a soil sampler as shown in Fig. 10 are collected in small glass vials and taken to a central laboratory for analysis. Pipe-to-ground potentials, together with pertinent facts, should be recorded. Visual inspections of the pipe are made in conjunction with the soil tests. The data may be recorded on the form shown in Fig. 11 when extremely detailed information is wanted. If it seems that the information on this sheet is more detailed than necessary for the purpose intended, a field inspection sheet similar to Fig. 12 may be used. Instructions for filling out these inspection sheets and the definitions pertaining to data on the inspection sheets are given in accompanying boxes.

The soil corrosivity data indicated in the lower part of the right-hand column of Fig. 11 is obtained by an instrument designed by the writer and shown in Fig. 13. This instrument evaluates theoretical pipe life and combines the principles evolved by Joseph F. Putnam[1]. Putnam correlated the data compiled from a comprehensive investigation on the subject of soil corrosion conducted by the U. S. Bureau of Standards over a period of more than ten years. Investigation covered many actual pipe samples that had been buried in each of 47 localities throughout the United States and in soils varying in textures from sand to clay and ranging in pH value from 3.5 to 10.

Fig. 14 shows the left-hand or title edge of a master sheet that may be employed to correlate all the data accumulated. Strips from pipe-line inventory or plat sheets may be cut and pasted in the blank space shown in the center of the sheet. The actual information may be summarized by plotting the data obtained. This will give a graphic correlation of all findings over the entire pipe line in a manner not possible when the data are only tabulated.

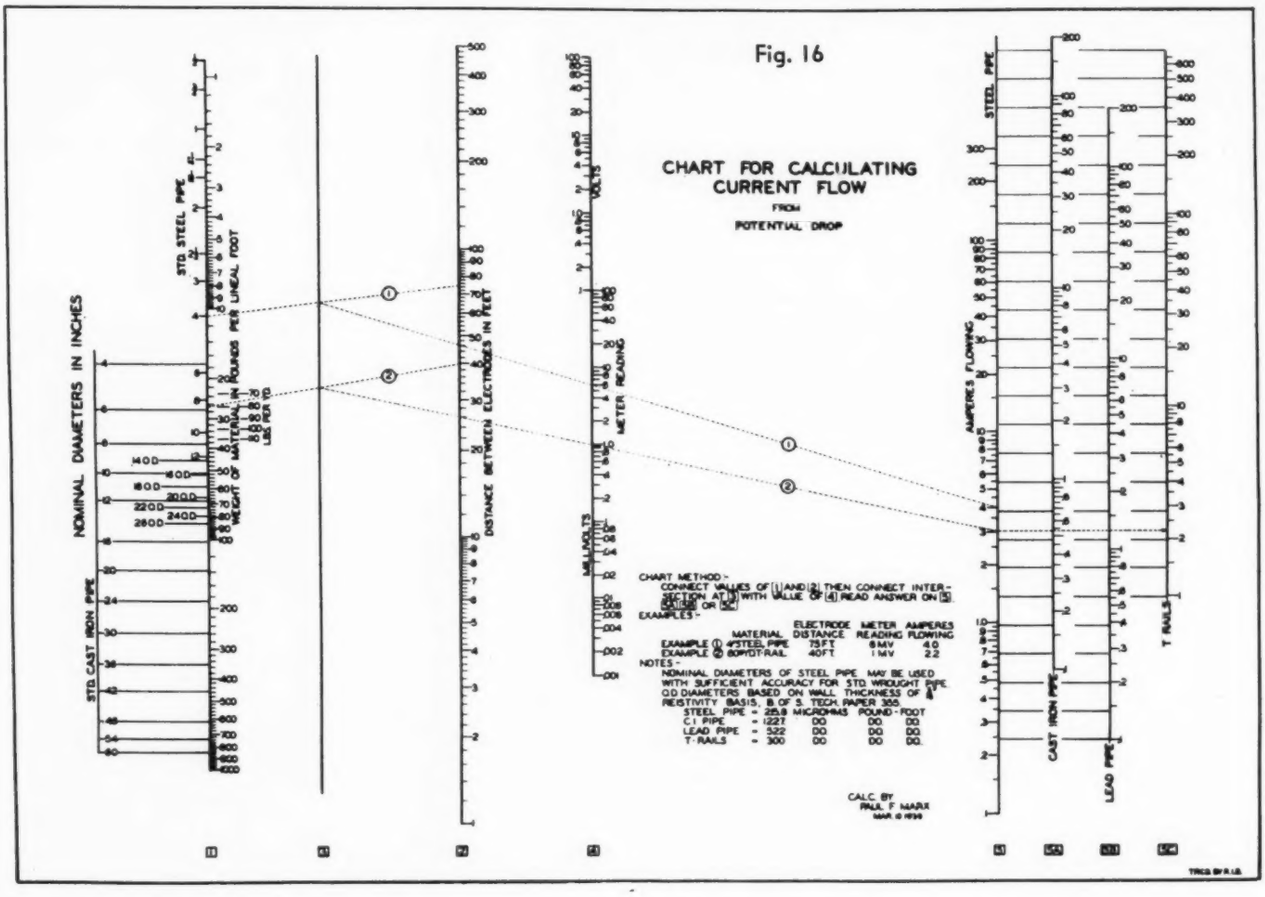
Fig. 15 may be used to obtain a percent penetration from pit depth-gauge measurements.

Many times where leaks have occurred from pin holes in welds or where pipe seams are leaking, the escaping gas "sours" the soil to such an extent that an electrolytic action takes place, thus causing severe pitting. A remedy for this condition is not to protect the pipe cathodically but to repair the leak and remove the soured soil. Such a soil has a definite foul odor.

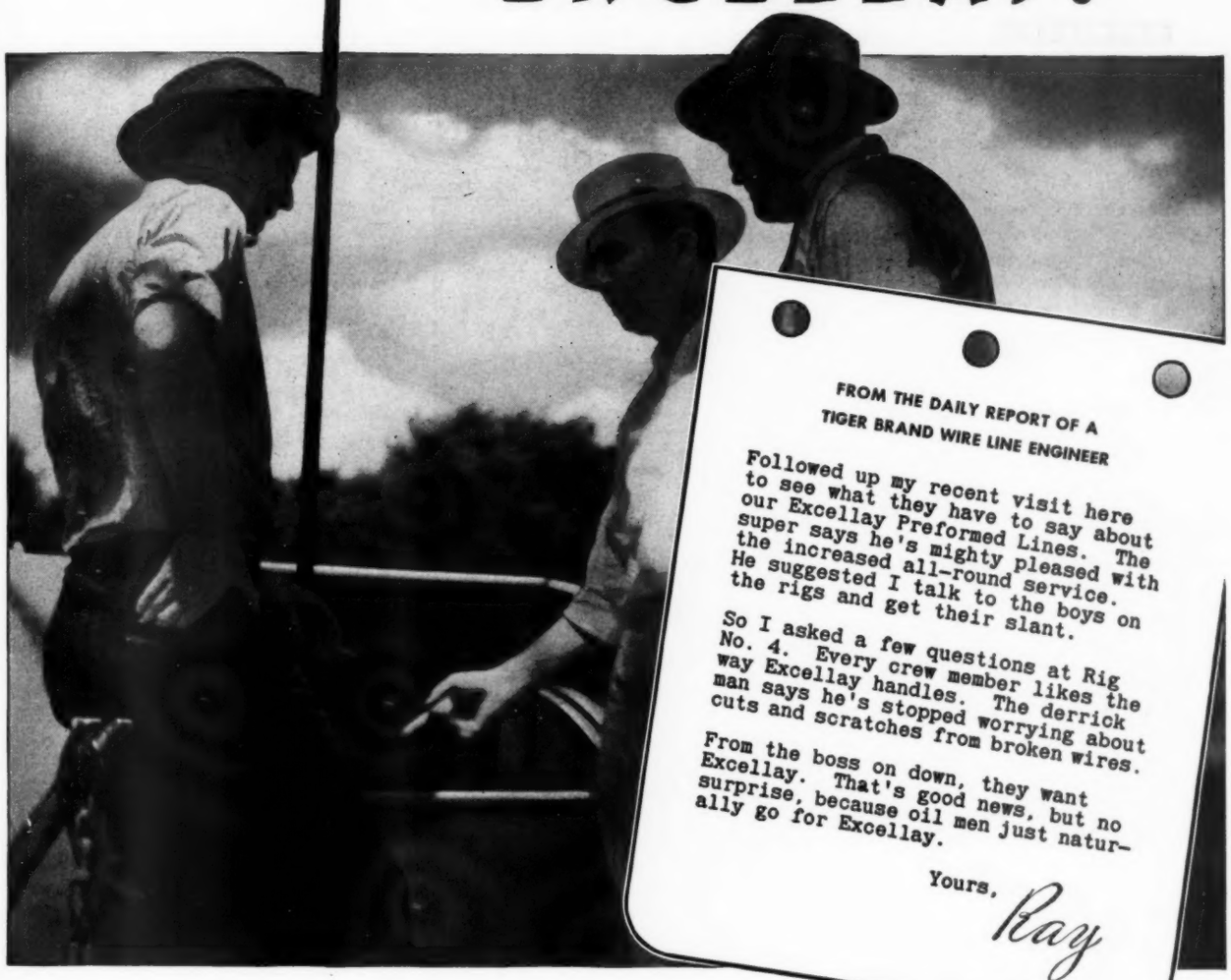
In taking potential drop measurements on pipe lines to determine the amount of current flowing on the line, electrodes similar to the one shown in Fig. 4 may be used. A millivoltmeter having approximately 300 ohms per volt should be used in series with the electrodes. A simple means of determining the amount of current flow by the potential drop method is shown on the chart, Fig. 16.

[1]Standard Oil Company of California.

Fig. 16



OIL MEN | JUST NATURALLY GO FOR EXCELLAY!



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Electrical Pyrolysis of Hydrocarbons

The voltolization process involving treatment by silent electrical discharge is an important means of producing premium motor oil having a high viscosity index—voltolization of gaseous hydrocarbons results in a maximum yield of gasoline

By RAFAEL FUSSTEIG

IT is more or less common knowledge that all types of decomposition of hydrocarbons require the influence of certain quantities of energy to split the higher-molecular hydrocarbons into lower-molecular compounds or to polymerize lower-molecular hydrocarbons into the so-called "polymers." To carry out these reactions the energy in the form of heat must be introduced to the hydrocarbon so that the heat may effect the splitting of the carbon-carbon and carbon-hydrogen bonds. These decomposition reactions may result in the formation either of fractions of gasoline-like character or of higher-molecular unsaturated hydrocarbons. Furthermore, these reactions require the use of certain "regulators" such as pressure and catalysts, the latter for the purpose of guiding the direction of the desired reaction.

It has been stated, however, by many investigators that another kind of energy and another "guide" of the reaction flow can also be employed in all types of decomposition and rearrangement reactions of hydrocarbons by using electrical energy during the pyrolysis of hydrocarbons. When a hydrocarbon is submitted to the action of a silent electrical discharge, its chain will be weakened in a corresponding linkage. The extent of the weakening will depend largely upon the strength or voltage of the silent electrical discharge.

The splitting of the carbon-carbon bond requires an electrical discharge of quite different intensity from that required in the splitting of the carbon-hydrogen bond of a hydrocarbon. In the first case the hydrocarbon will be split into smaller hydrocarbons; in the second case hydrogen atoms will be split from the hydrocarbon. Consider, for example, the behavior of ethylene during the two decomposition reactions; in the carbon-carbon decomposition reaction ethylene will be split into the labile, active $=CH_2$ molecules, which are then submitted to different reactions[1], depending upon the operating conditions. On the other hand, the carbon-hydrogen decomposition reaction causes the formation of acetylene and hydrogen.

[1] *The Petroleum Engineer*, October, 1937.

RAFAEL FUSSTEIG

together with his family, is now in Lwow, Poland, having been obliged to leave his headquarters in Jaroslaw when that city was occupied by the German army—He hopes soon to come to the United States to establish his permanent residence—Prior to the outbreak of the war in Europe he was professor of petroleum technology in the Ecole Superieure Technique et Commerciale de Paris, Paris, France, and maintained an office as consulting petroleum engineer at Jaroslaw, Poland.

In other words, the silent electrical discharge can either cause cracking of a hydrogen into smaller hydrocarbons, or cause a dehydrogenation of a hydrocarbon into stable and unstable hydrocarbons, the latter being then submitted to further polymerization reactions. Treatment of this type is termed the voltolization process. Voltolization of oils and other similar compounds is a method employing the action of a silent electrical discharge of high potential to produce premium motor oils having extreme high viscosity index and oiliness.

It is believed that the increase in viscosity of an oil after the voltolization process results from the dehydrogenation and subsequent polymerization of the remaining unsaturated hydrocarbons. The viscosity and the yield of the voltolized oil depend upon the intensity of the electrical treatment. The longer the period of voltolization the greater will be the volume of oil submitted to the dehydrogenation and polymerization reactions, and the higher will be the viscosity of the voltolized oil.

Of course, the velocity of the oil thickening during the action of the silent electrical discharge depends largely upon the nature of the oil. An oil predominating in paraffinic hydrocarbons will exhibit a different behavior during the electrical discharge than the aromatic or naphthenic hydrocarbons. The voltolization of oils of aromatic or naphthenic character requires more electrical energy than that of the paraffinic hydrocarbons. When a fat oil, that is, an oil of vegetable or animal origin, and a petroleum oil are voltolized to obtain the same increase of viscosity, the first will require less electrical energy than the latter. The reason for this lies in the different strengths of the carbon-hydrogen bonds in different types of hydrocarbons. This indicates that the unsaturated hydrocarbons can be easier voltolized than the saturated hydrocarbons. It is of great importance to learn the exact manner in which the hydrogen atoms are split from the hydrocarbon. As the electrical intensity increases, the scission will be displaced toward the middle of a paraffinic hydrocarbon chain and the double-linkaged bond and its neighboring carbon bond will be strengthened during the silent electrical discharge.

This results in a weakening of the subsequent bond, causing a splitting of the hydrogen atoms from the carbon-hydrogen bond. A. de Hemptime was one of the first to observe the dissociation of hydrogen atoms from different oganic compounds during the silent electrical discharge. Hemptime succeeded in carrying out various polymerization reactions of different organic compounds such as fats and mineral oils. The oils polymerized in this manner contained a high quantity of higher-molecular hydrocarbons that were very slow to react but which possessed valuable lube characteristics.

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These observations have caused many investigators to propose various patents pertaining to the improvement of inferior oils into valuable lube oils by means of the action of the silent electrical discharge. Wilhelm Nernst, perceiving the importance of the voltolization process, began the study of the physico-chemical foundations of this process. As a result of his experiments, Nernst believes that the transformation of oils under the electrical influence consists in the bump action of the gas ions that occurs during the silent electrical discharge causing a dissociation of hydrogen atoms from the hydrocarbons and a subsequent chemical reaction of the remaining unsaturated labile hydrocarbons among themselves to form higher-molecular complexes. In other words, the hydrocarbons of the oil will be split by the silent electrical discharge into positive and negative ions, these ions floating toward the corresponding electrodes.

This splitting takes place in the same manner as the ordinary electrical dissociation of inorganic compounds. During the electrical dissociation of, for example, potassium hydroxide, the positive potassium ions and the negative hydroxide ions are formed, the latter being then submitted to a chemical reaction. In the same manner the ionization of an oil occurs, in which positive hydrogen ions and negative hydrocarbon ions are formed, the latter being then submitted to different polymerization reactions among themselves. Of course, the split hydrogen ions will not always reach the corresponding electrode as a free component as they may enter into chemical reaction with various active hydrocarbons encountered. Consequently during the voltolization of oils not only pure polymerization reactions take place but different rearrangement reactions also occur in which the split positive hydrogen ions play an important role in determining the hydrocarbons formed.

In other words, the ionization of the oil is accompanied by certain reactions in which the carbon-carbon bonds are dissociated from the hydrocarbons during the silent electrical discharge. In the latter case the silent electrical discharge, acting as a catalyst, is able to execute a splitting between proper carbon-carbon bonds of a hydrocarbon. In reality, there is no great difference between the catalytic action of a catalyst and that of a silent electrical discharge.

In the first case, the catalyst is able, according to the hypothesis of the writer, to split the hydrogen and carbon from the hydrocarbon compound not only into atoms but also into electrons. These electrons then combine with the readily-movable electrons of a catalyst. Likewise the hydrogen and carbon ions adhere to the surface of the catalyst, being able in this form to enter into chemical reaction among themselves. Of course, the carbon atoms when submitted to the same action undergo a transformation in which the carbon having four active linkages is changed into carbon having two active linkages.

From the above, it is evident that proper chemical reactions between carbon and hydrogen are dependent largely upon the action of the electrons in the structure of the catalyst. Considering that electricity is a movement of certain electrons on the surface of a metallic wire, we may conclude that the catalytic action of a catalyst on the hydrocarbons during the pyrolysis is also the consequence of similar electrical actions.

In other words, two processes occur during the electrical pyrolysis, the first being the so-called ionization, the second being the "electronic bombardment" of the hydrocarbon atoms. During the ionization process only a splitting into hydrogen and unsaturated hydrocarbon parcels takes place, the latter being then subjected to different polymerization reactions; the "electronic-bombardment" process causes true cracking reactions of higher-molecular hydrocarbons into lower-molecular compounds. Ionization causes the so-called voltolization in which inferior oils are transformed into lube oils of high quality; the electronic-bombardment process results in the production of gasoline by the splitting of higher-molecular hydrocarbons.

Temperature plays an important part in the electrical silent discharge during the pyrolysis reactions. The higher the temperature the better the reactions occur during the electrical action. Of course, the temperature limits during the operation should be watched, as for each oil there is a maximum temperature that should not be exceeded.

The voltolization process has been known for a long time and many patents have been proposed. The German "Voltol Process"[2] is carried out in such a way that 30 to 50 tons of charging oil is heated in a closed, cylindrical vessel to a temperature of about 80°C. under a vacuum of 60-70 mm. This heated oil then passes over aluminum electrodes and thus is submitted to the action of the silent electrical discharge. These silent electrical discharges are produced by using alternating current of about 5000 volts. To prevent undesired oxidation reactions under these extreme operating conditions, this process is carried out in the absence of air by using an inert gas such as nitrogen. By employing this process, mineral oils, fatty acids, etc. can be transformed into voltoils of high viscosity.

Siemens and Halske[3] treat hydrocarbons and fatty oils with a-c. discharges using two electrodes situated beneath the level of the liquid. When using an alternating current of a high frequency under a reduced pressure, the oil will spume and very pure hydrogen will be produced. Simultaneously the remaining unsaturated hydrocarbons undergo polymerization reactions and are transformed into desirable oil.

Thus, for example, when treating 150 cu. cm. of a machine oil, whose absolute viscosity is 0.302, by the voltolization process using glass electrodes and an alternating current at a frequency of about 500 cycles per sec. and a potential of 600 volts, the absolute viscosity of the oil will be increased to 0.466 when 1 kw. of energy has been absorbed. When 2 kw. has been absorbed the absolute viscosity will increase to 0.785.

This process has the two advantages of (1) producing lubricating oils of very high quality and (2) producing large volumes of hydrogen so pure that it can be used in the solidification of edible fats. Another patent[4] proposes the mixing of an oil with a finely-pulverized substance, and then submitting this mixture to a high-voltage, high-frequency electrical current. Using this method, a petroleum distillate having a boiling point of 180 to 250°C. and a very low viscosity such as 1.1 deg. Engler at 20°C. when mixed with 2 percent of charcoal powder and submitted to the electrical action in an ozonizing pipe (voltolization apparatus), will be transformed into a lubricating oil of a high viscosity (2.3 deg. Engler at 100°C.).

A very interesting method is proposed by "Oelwerke Stern Sonneborn, A. G." and E. R. Vogel[5]. In this process, hydrocarbons are treated with a-c. discharges in a condenser whose plates are completely separated from the liquid by a dielectric. The treated liquid will first be dispersed into a spuming form by using an inert gas and is then submitted to a current of high voltage and frequency. This method produces lubricating oils of very high viscosity.

In the event, however, that active gases are used instead of the inert gas the hydrocarbons will enter into chemical reaction with these gases. Thus,

[2]D. R. Patent 234, 543, and 236, 294.

[3]D. R. Patent 466, 813.
[4]F. Patent 368, 102.
[5]Austria Patent 114, 104.

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when hydrogen is introduced during the action of the silent electrical discharge on unsaturated hydrocarbons, it enters into reaction with these hydrocarbons, resulting in their saturation. Consequently, unsaturated oils, fatty acids, etc., can be transformed into higher-molecular saturated hydrocarbons. Of course, unsaturated hydrocarbons can also be submitted to the action of the silent electrical discharge in the absence of hydrogen. In this case the unsaturated hydrocarbons will be split into hydrogen and higher unsaturated hydrocarbons that are then polymerized to still higher-molecular unsaturated hydrocarbons. To cause a splitting of hydrogen from unsaturated hydrocarbons a current of even higher voltage and frequency should be applied. The reason for this lies in the fact that the hydrogen atoms combined in the saturated hydrocarbons are more readily dissociated than are the hydrogen atoms combined in the unsaturated hydrocarbons.

If we consider that during the electrical silent discharge the ions attack the molecules of the oil with great strength in dissociating the hydrogen atoms, it is evident why a stronger current must be used in splitting stronger carbon-hydrogen linkages. Likewise this explains why the voltolization of saturated hydrocarbons requires less electrical energy than that of unsaturated hydrocarbons. Voltolization of unsaturated hydrocarbons also may be employed to polymerize unsaturated acids into higher-molecular acids. Thus, oleic acid can be transformed into stearic acid by using the silent electrical discharge.

From the above, it may be concluded that the voltolization process can be carried out directly or in the presence of hydrogen. Hydrogen, however, is not the only gas that can be introduced in this process to obtain a chemical reaction. When oxygen is employed to cause a spuming of the liquid unsaturated hydrocarbons, it will be activated by the silent electrical discharge, resulting in the oxidation of the hydrocarbons. Thus unsaturated hydrocarbons can be transformed into alcohols, aldehydes, ketones, etc. Of course, when an oil is submitted to all the abovementioned processes under the action of the electrical silent discharge, a part of the unreacted hydocarbons always remains and must be removed by vacuum distillation.

The above discussion indicates that the voltolization process can be used in producing various hydrocarbons. Not only lubricating oils, but also different oxy-hydrocarbons can be produced by the action of the silent electrical discharge. Of course, each modification requires proper operating conditions. The manufacture of lubricating oils, however, can be considered as the most important operation in the voltolization process. Voltolization of lubricating oils shows many economic advantages, the most important being that the increase in viscosity during the voltolization does not increase the oil losses but only improves the chemical properties of the polymers. The color remains unchanged, and the flash point shows a very small increase in comparison with the increase in viscosity. The increase of the viscosity index as a result of voltolization is much greater than is possible by solvent treating, and the oiliness of the oil is remarkably improved.

Consider now the decomposition of higher-molecular hydrocarbons into lower-molecular compounds using electrical energy. This decomposition must be carried out so that a carbon-carbon bond of a hydrogen is split, resulting in the formation of two or more particles from one hydrocarbon molecule. Therefore the electrical conditions during the splitting process must be such that the linkage between two carbon atoms is weakened. In this case the ions attack the oil molecule so actively that certain carbon-carbon linkages are split. Of course, during this action certain ions also attack the carbon-hydrogen linkages to produce hydrogen atoms. This ionization is essential in obtaining a proper migration of hydrogen atoms during the rearrangement of hydrocarbons.

On the other hand certain ions bound against the carbon atoms and split them from the hydrocarbon, after which these carbon atoms of four active linkages are transformed into carbon atoms of two active linkages. The latter then enter into chemical reaction with the active hydrogen atoms forming $= CH_2$ molecules, which can be considered as the labile form of the very active starting material in the polymerization to gasoline-like hydrocarbons. W. D. Harkins and D. M. Gans[6] have studied the spectroscopic decomposition and rearrangement reactions of organic compounds during silent electrical discharges and have stated that, for instance, benzol or naphthalene when submitted to the action of the silent electrical discharge were split in the first phase into CH-molecules, carbon molecules, carbon atoms, hydrogen atoms, and positive-charged carbon atoms. These split particles, being extremely active, enter immediately into chemical reactions among themselves, resulting in various polymerization reactions.

According to the hypothesis of the writer, the ionization and the electronic-bombardment of hydrocarbons during the action of the silent electrical discharge not only cause the abovementioned splitting action but also result in the formation of carbon atoms of two very active linkages that unite with active hydrogen atoms to form the active $= CH_2$ molecules. The latter then enter immediately into chemical reaction either among themselves or with other carbon atoms, or even with the split hydrocarbon particles. It is evident that the starting oil must first be heated to a proper temperature before being submitted to the action of the silent electrical discharge.

Of course, electrical energy can be used in the cracking of hydrocarbons either as a heating source or as a decomposition agent or both. Leffler, Grevenbroich, and van Beregen[7] have patented a method for producing a gasoline from higher-molecular hydrocarbons using electrical energy in the liquid phase as a heat source and as a decomposition agent. The electrical resistances cause the production of necessary heat and the favorable conductibility of the hydrocarbons during the pyrolysis. This conductibility is obtained by using the electrical resistance of a quantity of small tubes. Consequently, a large heating surface is obtained, and the decomposition reactions that occur lead to the formation of lower-molecular hydrocarbon liquids.

It should be noted, however, that when the charging oil is submitted to the electrical decomposition process in the liquid phase, the electrical heat plays a more important role than the silent electrical discharge. The reason for this lies in the fact that the discharge is unable to cause the so-called depolymerization reactions that are necessary to the formation of higher-molecular hydrocarbons. Therefore, when an oil in the liquid phase is submitted to a silent electrical discharge only a current of very low tension and frequency should be applied, as it serves only as a catalytic reaction regulator. Consequently, the electrical cracking of oils in the liquid phase should be controlled so that the starting oil is first heated to a proper temperature by means of the electrical energy, and is then submitted to a very weak electrical discharge, which, as a catalytic regulator, guides the flow of proper reactions.

The action of the silent electrical discharge on hydocarbons in the vapor

[6] *Am. Chem.*, 1930, pp. 5166.

[7] D. R. Patent 527, 699.

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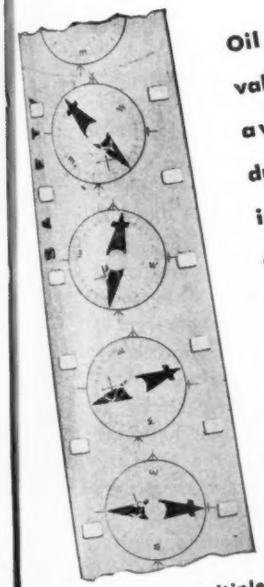

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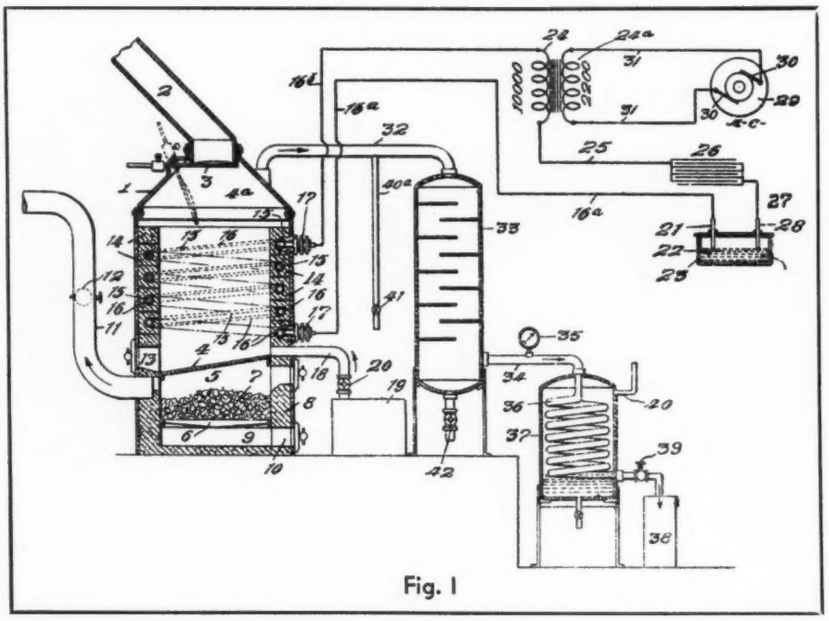


Fig. 1

phase leads to quite different results. When the hydrocarbons in the vapor form are directed through an apparatus in which silent electrical discharges occur, the ionization and the electronic bombardment of these hydrocarbons will occur with such violence that a maximum yield of gasoline is formed. There are many patents incorporating this principle, the most important being that of the C. and C. Developing Company[8]. In this proposal, liquid hydrocarbons in the vapor state are transformed by heating them to about 400°C. and directing the heated gases into a special reaction chamber wherein they are submitted to silent electrical discharges of very high frequencies. As the hydrocarbon gases arrive in the sphere of the electrical discharge, corresponding decomposition reactions occur, resulting in the formation of gasoline in the second reaction phase.

Theoretically, in this electrical cracking process, it appears that the oscillation field of high frequency and a proper temperature is able to cause a dissociation of hydrocarbon molecules in the vapor phase, resulting in a change of polarity of the electrons. In other words, the positive electrons vibrating in the electrical field change their polarity under the action of the electrical oscillation of high frequency. In this state the thus activated carbon atoms enter into chemical reaction with migrating hydrogen atoms of the hydrocarbon molecules. Of course, these hydrocarbon gases can also be hydrogenated in the oscillation field of high frequency.

It is well known that crude petroleum contains comparatively small amounts of disposable hydrogen so that the cracking process yields only about 50 percent of gasoline and the remaining hydrocarbons deficient in hydrogen are polymerized into resin- and asphalt-like compounds. To avoid these polymerization reactions and obtain more favorable gasoline formation, artificial hydrogen must be added in the reaction field. In the abovementioned process the added hydrogen will be directed to the oscillation field of high frequency countercurrently to the hydrocarbon vapors. At the moment the electrons of the split hydrocarbons change their polarity, they become very active and enter into reaction with the outside hydrogen atoms.

J. W. Henry proposes an interesting method[9] of destructive hydrogenation, using the electrical discharge. Fig. 1 shows the flow sheet of this process.

The apparatus consists of a shell still (1), a bubble tower (33), and a cooler (37). The still (1) is covered by a layer of fire brick, in which holes are joined to form horizontal openings. In these holes, that is, in the interior of the bricks, an electrical conductor (15) of a second electrical circuit is placed. This conductor is covered by an asbestos layer (16). Thus, the wire itself is insulated by a layer of asbestos and the conductor, being surrounded by the bricks, does not permit contact with the starting material.

One end of the conductor (15) passes through the vertical wall of the still and, flowing through the wire (16b), arrives at the transformer (24) that is joined with the condenser (26). A conductor (27) joins the condenser and the copper electrode (28). The other end of the conductor leaves the still in (17) and going through (16a) is connected with the second copper electrode (21), these two electrodes being plunged in a mercury layer (22). The primary of the transformer (24a) is connected with an a-c. dynamo (29). The 2200-volt current produced provides an oscillation current of high frequency.

During the electrical operation an arc is formed between the copper electrodes (21) and (28), producing an oscillation that determines the frequency of the current. This electrical arc produces oscillations that result in the necessary frequency of about 50,000 cycles per sec. The destructive hydrogenation operation in the abovementioned patent is described as follows: The still (1) is filled with a heavy oil or a solid fuel as coal, bitumen, etc., which is then heated to a temperature of about 480°C. At this temperature, the starting material is submitted to the action of the silent electrical discharge. This results in the ionization and electronic-bombardment of hydrocarbons which, in this state, are very active and are readily hydrogenated by means of the outside hydrogen atoms.

Hydrogen, directed from the vessel (19) to the still (1), enters into chemical reaction with split particles in the oscillation field to produce lower-molecular hydrocarbons. Thus not only liquid hydrocarbons but also solid compounds can be hydrogenated, the first being transformed into gasoline, the second into benzol. When a solid compound as coal or bitumen is submitted to the electrical destructive hydrogenation, it must first be mixed with certain amounts of limestone before being charged into the still. The reason for this lies in the fact that coal when mixed with limestone decomposes at lower temperatures than when alone. In addition, the limestone facilitates the ionization of the carbon atoms of the coal, so that they may enter readily into reaction with the outside hydrogen from (19).

After the electrical rearrangement of the hydrocarbons and carbon atoms and the subsequent hydrogenation of the vapors, these vapors are directed to the bubble tower (33), in which separation from the free coal particles, asphalt, and higher-molecular hydrocarbons takes place. Then the gases pass to the cooler (37), where the separation of gasoline or benzol from the stable gaseous hydrocarbons takes place.

[8]U. S. Patent 1, 856, 828.

[9]F. Patent 617, 491.

High-Temperature Cooling of Internal-Combustion Engines

WITHIN the last two years industrial interest in the development of motive power by the use of internal-combustion engines fueled with regular metered city gas has grown so rapidly that recent reports made by the Gas Engine Power Committee, Industrial Gas Section, American Gas Association, concerning better methods of waste-heat utilization in connection with gas-engine applications will be of profit-producing concern to power-using industries. The improved procedures involve what is known as "high-temperature cooling" of internal-combustion engines, and are based upon the use of jacket cooling-water at temperatures greater than 212° F.

To date, jacket-water and exhaust-gas heat from gas engines have been used either: (1) to heat water for a variety of uses (boiler make-up, washing operations, space heating, or heat-exchanging operations in any number of chemical and thermodynamic operations), (2) to generate steam (for plant heating, equipment sterilization, or processing usage), or (3) to produce warm air (for space heating, or drying operations). The usual method is to conduct the heated cooling-water within a closed system through some type of heat-exchanging coil, and to capitalize upon the exhaust-gas heat (if at all) either by: (1) conducting the exhaust gases directly through a second heat-exchanging device such as a warm-air heater or a boiler, (2) water-jacketing the exhaust line and connecting it as a temperature "booster" in series with the engine-cooling-water system, or (3) water-jacketing the exhaust line and using it to heat water in a circulating system separate from the engine-cooling-water system. These methods are all discussed in detail in a special chapter of the recent and first complete "Gas Engine Handbook," published by the Industrial Gas Section of the American Gas Association and available from its headquarters, 420 Lexington Avenue, New York, N. Y., at $1.00 per copy. The information herein discussed covering further possibilities of "Waste Heat Utilization with High-Temperature Cooling of Internal Combustion Engines" has been developed subsequent to the publication of the A.G.A. handbook and is supplementary thereto.

The following is an abstract of a report on tests made in Southern California, written by D. W. Reeves, Oklahoma Natural Gas Company, Tulsa, chairman, A. G. A. Gas Engine Power Committee for 1940:

"Because of the fact that engine jacket water is generally maintained at temperatures under 200° F., it has been difficult to use such water directly without additional heat being supplied from some outside source other than the engine itself.

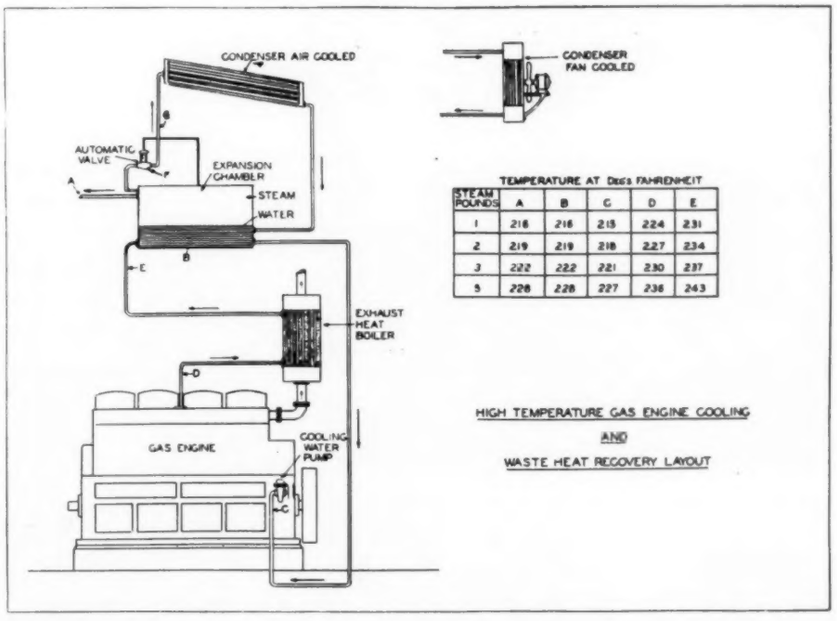
"Experiments have been carried on during the past few months in Southern California, following several years of development work abroad, in the high temperature cooling of internal combustion engines. By 'high temperature cooling' it is meant that instead of maintaining jacket water temperatures of approximately 160° F., the temperature is raised to 215° F. and over. In some instances, temperatures of jacket water from 300° to 400° F. have been tried; however, at these higher temperatures, lubrication difficulties have been experienced. At the lower temperatures, from 220° to 250° F., no mechanical difficulties have been encountered. * * *

"There is an added advantage to be derived from high temperature cooling, namely the automatically controlled heat balance obtained thereby.

"For example, when an engine jacket water temperature of 160° F. is maintained with water circulating through an engine at the rate of approximately 50 gallons per minute, it is quite possible that there will be times when the consumer will not require the heat in the full 50 gallons per minute, or it will be to his advantage to use less than that amount. When engine temperatures are maintained below the boiling point, for example, 160° F., the heat from the engine jacket water and exhaust, if used for outside purposes, must be recovered at a continuously uniform rate. If all of the heat is being absorbed in a heat exchanger at one time and only a portion of the heat is absorbed or used at another period during operation, the operating temperature of the engine so fluctuates as to cause considerable difficulty in operation.

"It is likewise essential that the temperature differential between incoming and outgoing water from engine water jackets be maintained at a minimum of not over 20° F. This is exceedingly difficult where the waste heat from the engine water jackets and exhaust is being utilized for outside purposes with temperatures under 212° F. At the higher temperature it is possible to take all or any portion of the heat without upsetting the balance in the engine.

"The foregoing is, of course, only one of the many examples of how the new principle of high temperature cooling may be used in increasing the over-all thermal efficiency of a natural gas power unit. It represents a great potential saving in operating costs where it may be used to advantage.



TEMPERATURE AT DEGS FAHRENHEIT

STEAM POUNDS	A	B	C	D	E
1	216	216	213	224	231
2	219	219	218	227	234
3	222	222	221	230	237
5	228	228	227	236	243

HIGH TEMPERATURE GAS ENGINE COOLING AND WASTE HEAT RECOVERY LAYOUT

Steels-like men-may grow tired!

Overwork tires steels—causes fatigue—induces failures.

Larger sections to withstand the stresses do not invariably give the answer.

Today, weight and space limitations demand that smaller sections carry higher loads—safely—so the answer must be *alloy steels.*

Research into the behavior of steels subjected to repeated stress has taught steel users and makers that steels of the same tensile or hardness do not mean the same fatigue properties. Rather, the load-carrying ability of a steel depends upon the alloy constituents and the form of the structure at the time it is carrying the load.

This makes these attributes of Republic Alloy Steels worth your while to remember—

1. **They harden uniformly and easily.**
2. **They can be drawn back after quenching at a higher temperature for the same end point hardness.**
3. **The quench structure is more uniform than that of other steels.**
4. **The structure in the normalized and drawn state is more uniform.**

This table illustrates the importance of selecting the correct alloy, showing the fatigue limits on two steels treated to show the same tensile and hardness.

FATIGUE LIMITS—POUNDS PER SQUARE INCH

Steel and Treatment	On Polished Specimen	Specimen with notch 1/8" radius, 1/8" deep	Specimen with notch 1/16" radius, 1/16" deep
S. A. E. 1045—normalized and tempered to tensile strength of 85,000 to 90,000	38,000	35,000	31,000
.25% carbon, 2.75% nickel steel—normalized and tempered to same tensile strength	52,000	47,000	41,000

From left to right in the table, the stress concentrations become increasingly severe and, under the worst conditions shown, the alloy steel has a fatigue limit higher than the un-notched and polished carbon steel specimens.

★ ★ ★

Since so many factors affect the "fatigue limit" of a part, the selection of the correct alloy steel and the details of its heat treatment is a matter in which the experience of the world's largest producer of alloy steels can help you. Write Republic Steel Corporation, Alloy Steel Division, Massillon, Ohio; General Offices, Cleveland, Ohio.

When a manufacturer of drilling equipment tells you that he uses Republic Alloy Steels and Republic Metallurgical Service—you know that you are assured the kind of performance from his equipment that helps you make a profit.

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"The operation of an engine using the high temperature method of cooling is best shown in the accompanying illustration. It illustrates an installation where a condenser may be installed on the roof, either cooled atmospherically or by means of a fan. The expansion chamber B contains water at 212° F., which is at the boiling point and where it starts to liberate steam. The water leaves the expansion chamber, passing through the main cooling water circulating pump. By the time the water enters the engine, the temperature has dropped to approximately 211° F. Passing through the engine, the water will increase in temperature to approximately 220° F.

"As the water leaves the engine and is passed through the exhaust heat exchanger or boiler, the temperature rises to 227°F. The water at 227°F. mingles with the water in the expansion tank, and is dropped to 212° F. The steam liberated in the expansion chamber may be led away through pipe A for any indirect heat usage desired, the condensate being returned to the expansion chamber (not shown).

"An automatic valve F is installed in the line G connected to the condenser. This valve is set from one to two pounds above the pressure of the steam being used at A. Should the requirements for steam at A decrease or cease entirely, the pressure in the expansion tank will rise, the automatic valve F will open and the steam generated will pass through the condenser, from which it will return to the expansion chamber.

"Usually atmospheric pressure steam is not sufficient for average plant requirements, and in consequence, the pressure must be raised to obtain the higher temperatures. A table of temperatures at various points in the system is given in the illustration for pressures from one to five pounds in the expansion chamber.

"Where a tank of water is to be heated, the engine water (or steam from the expansion chamber) may be taken direct to a heat exchanger located in the water tank and then returned as condensate.

"Where the waste heat from the engine is desired for space heating, unit heaters or condensers may be installed wherever the heating is required and the engine water (or steam from the expansion chamber) may be piped to and from the individual unit heaters (used as condensers when steam is generated).

"When warm air is desired from gas-engine 'waste' heat, it is not necessary to install condensers equipped with motor driven blowers or fans near the engine, with an elaborate and expensive system of duct work to the locations in the plant where the heat is required. The piping of the engine water, or steam, is much simpler and requires less space with only a slight addition in power required for the circulating pump, which will be more than offset by the smaller blower needed at the point of heat application. The heat losses in the system where engine water, or steam, is piped to and from the unit heaters, will be appreciably lower than where the heated air must be transmitted through long ducts to various portions of the plant.

"The high temperature method of cooling natural gas engines makes available from four to five pounds of steam at 230° F. per brake horsepower developed by the engine. For example, with a 120 horsepower engine operating at full load, driving a 75-kilowatt electric alternator, approximately 480 pounds of 230°F. steam could be obtained from the engine for auxiliary heating."

P 516.5

Protecting Pumping Equipment From Flood Waters

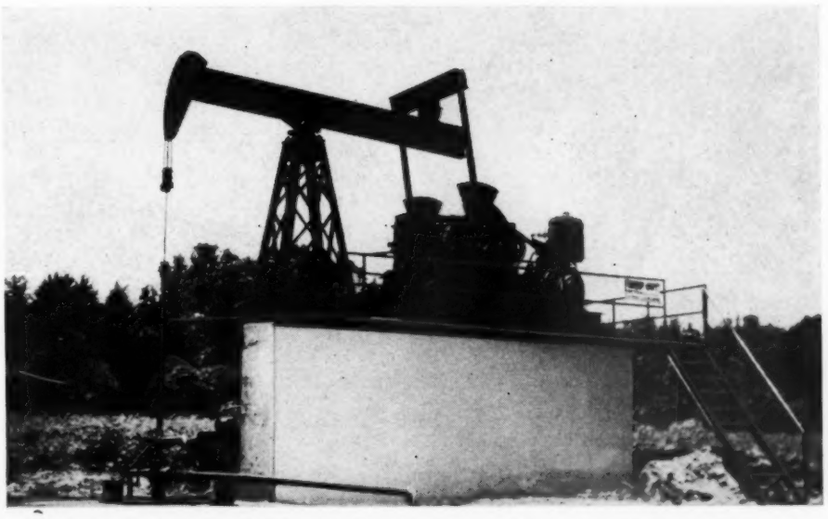
By EARL L. ALLISON

IN addition to the normal problems caused by the weather in Illinois and Indiana, operators in the comparatively new fields of Wabash County, Illinois, are confronted by the danger of flood waters from the nearby Wabash River.

In the accompanying photograph is shown the method by which one of the producing companies in the area insures uninterrupted operation of its pumping wells. The concrete pier supporting the pumping jack is designed so that its top is above the highest flood level ever recorded in this vicinity.

The well shown was one of the initial tests in Wabash County. Situated in a bend of the Wabash River, the rains of last winter and spring caused drilling operations to be suspended on several occasions. In fact, it was not until summer, after the rains had stopped, that the well could be completed.

After an experience of this kind, the owners of the well resolved to guard against recurrent trouble from high water by elevating the pumping equipment.



Pumping jack in the Wabash River basin is raised above high-water level to permit uninterrupted operation

No matter how high the river gets, the flood waters will not interfere with operation of the pumping jack and of the lead line to the distant receiving tanks.

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● With wells varying as they do in depth, corrosiveness and daily fluid requirements, low-cost-per-barrel cannot be accomplished without an accurate knowledge of pumping conditions.

Then this knowledge must be reduced to simple, usable terms—and in that respect the Jones Organization has made much progress and won many friends.

Being able to explain this information accounts for the many requests our field representatives get for data. Being able to use this information accounts for the many improvements which Jones has introduced in the metallurgy, design and manufacture of sucker rods.

Furthermore, it is only natural that this organization should expand into other phases of artificial oil lifting.

Whether you lift oil with or without sucker rods, you'll find Jones Service helpful and valuable.

● As a further broadening of our services in the field of low-cost oil recovery, we now offer the Jones-Staggs Intermitter for use where gas is available.

The S. M. JONES Co.

Jones Sucker Rods . . Jones-Staggs Intermitter

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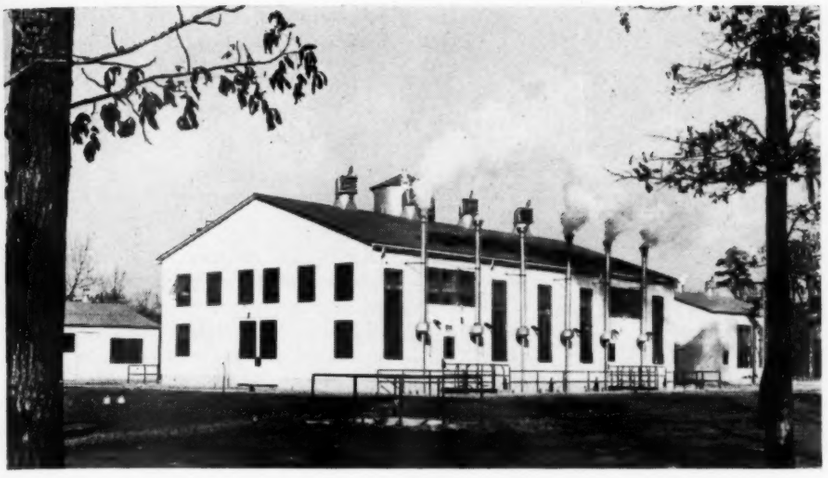


Newly-erected compressor station near Jackson, Mississippi

Many Construction Problems Involved in Laying of New Gas Line

Crossing of Mississippi River at Vicksburg, laying of pipe in swamps and in soil susceptible to erosion, taxed ingenuity of construction personnel in laying line from Monroe, Louisiana, to Jackson, Mississippi

By FRANK H. LOVE
Managing Editor

UNITED Gas Pipe Line Company has completed a construction project involving the laying of 156.3 miles of line to increase the gas supply to its Mississippi pipe-line system, necessitated by a decline in production of wells in the Jackson gas field, Mississippi.

The principal part of the project was the laying of an 18-in. trunk line from United's Sterlington compressor station, in the Monroe gas field, Louisiana, to Jackson, a distance of 124 miles, and the erection of a compressor station at the latter point. The completion of this line gives United an integrated system from Monterrey, Mexico, to Pensacola, Florida.

The new gas supply is from the Sligo, Sibley, and Lake Bistineau fields in the Shreveport area, and it is delivered to the Sterlington station through the Arkansas Louisiana Gas Company's system. To gather the gas from the producing fields and deliver it into Arkansas Louisiana's 20-in. line at a point near Minden, Louisiana, 7 miles of 14-in. line was laid from Sligo field to Koran and 4.5 miles of 8-in. from Lake Bistineau field to Koran; from the latter town a 20-in. line 18 miles in length was laid to the tie-in near Minden. The Sibley field is tied-into the 20-in. line at the town of Sibley by a 1.8-mile, 4-in. lateral. At Sterlington 1 mile of line was laid between United's Sterlington station and Arkansas Louisiana's Munce station.

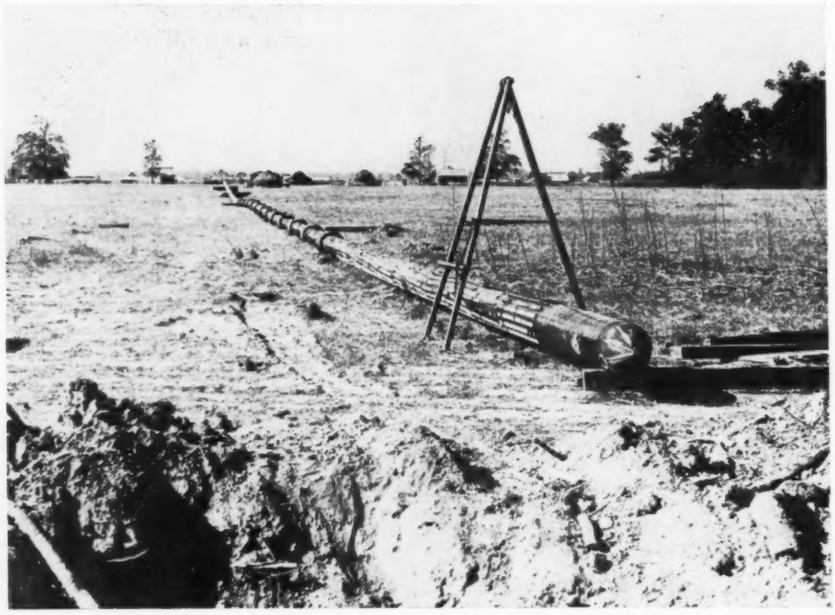
Actual laying of the pipe began on September 27 and the line was ready for transportation of gas on December 5. Unusually open weather for the time of year materially aided the construction crews, particularly on that section west of the Mississippi River where numerous bayous and swamps were encountered.

In laying the line a combination of electric-welded and coupled joints was employed. General practice was to weld three joints of pipe, then use a coupling. When the terrain was too rough or too swampy this program was impracticable and in such instances it was necessary to weld longer sections, usually about 1000 ft. in length.

The greater part of the low country, marshes, bayous, and river bottoms, was between Monroe and Delhi. Over the entire length of the line multiple crossings were made of Bayou De Siard, Little Lake, Lake LaFourche, Boeuf River, Big Creek Lake, Bayou Macon, Joe's Bayou, Tensas River, and Lake One, in Louisiana; and in Mississippi, Big Black River and Pearl River. In addition, the Mississippi River was crossed at Vicksburg, but as this was a major undertaking in itself, it will be discussed separately.

All river crossings were made multiple, having 18-in. headers. Six crossings consisted of two 14-in. lines, two had three 12-in. lines, and three had five 10-in. lines. River clamps weighing 1000 lb. each were used on all river crossings, their spacing depending on the diameter of the pipe. Pipe was coated and wrapped by machine and lath were wired to the outside surface to prevent damage to the wrapping and coating when pulled or pushed across the stream.

United has devised a simple, but effective, piece of equipment for use in clearing a path across shallow streams, bayous, and swamps when it is impossible or undesirable to lay the pipe in a ditch. A section of pipe approximately 10 ft. in length and of large diameter is torch-cut at each end in a manner resembling the teeth of a saw. These teeth are then flared-out at an angle of 45 to 90 degrees. The section of pipe is weighted by river clamps, a plug is placed in each end, and a winch-line fastened to each plug. Tractors or winch-trucks on both sides of the body of water operate the lines and by drag-



A string of 14-in. pipe ready to be pulled into place at the Big Creek Lake crossing. Note the lath wired to the outer surface to protect the coating

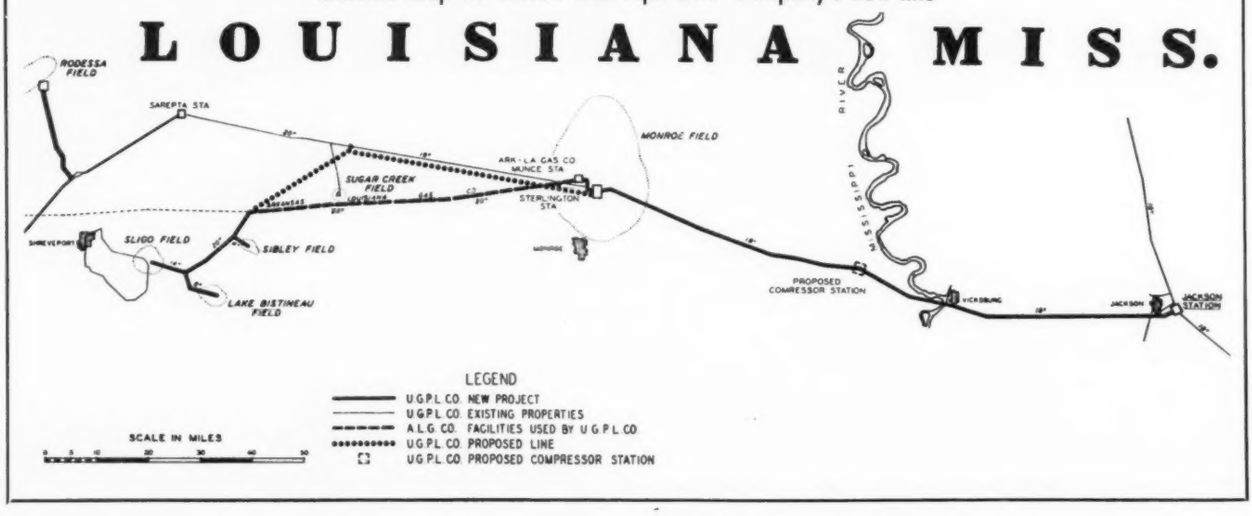
ging the apparatus back and forth remove all stumps and boulders and provide a shallow depression into which the pipe is placed. The apparatus was used to good advantage on this project because of the many shallow rivers, swamps, and bayous that were crossed.

From the Mississippi River eastward toward Jackson the terrain is extremely rugged for the first 15 miles and the surface formation is a fine sandy loam readily susceptible to erosion. On abrupt slopes it was necessary to riprap the ditch with bags of earth to protect the backfill. An accompanying sketch shows the manner in which this was done. This sketch illustrates one of the longer slopes. In instances such as this a series of dams was made across the ditch by use of earth-filled bags, extending from the pipe line to the surface of the ground. The pipe line between the dams was protected against erosion in the bottom of the ditch by a double row of earth-filled bags. When the slope was shorter the practice was to build a dam across the ditch only at breaks on the slope where wash or erosion were considered likely to occur.

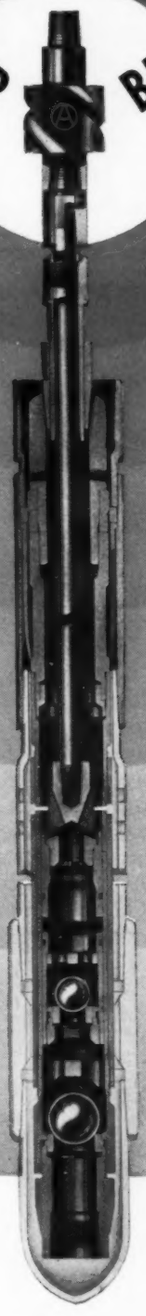
Crossing of the Mississippi River at a point near Vicksburg constituted one of the highlights of the line's construction. A contract was negotiated with the Vicksburg Bridge Company for use of that structure as a support for the pipe line. The 18-in. line, as it approaches the river, is parallel to the bridge proper, and just before reaching the levee to the west ties-into an 18-in. header. From this header two 14-in. lines extend, pass over the levee, thence underground alongside the steel trestlework of the bridge to a point approximately 700 ft. from the west portal of the bridge. At this point the two lines rise vertically about 50 ft. to the bottom members of the steel trestlework. The two lines then extend side by side on these girders, resting on metal rollers, until the west portal of the bridge is reached. In each line in the section supported on the steel trestlework is a hairpin expansion joint to allow for pipe movement resulting from temperature changes. At the west portal of the bridge the lines emerge from beneath the steel trestle and follow the north side of the bridge proper, being supported, one directly above the other, by rollers set in steel brackets, the latter being welded onto the bridge steelwork. At two places on the bridge large expansion bends have been installed on each line. As the lines pass the east portal of the bridge they swing beneath the steel trestle and are supported as on the west end of the bridge. This section also contains a set of hairpin expansion joints. After reaching the end of the steel trestle the lines drop vertically approximately 40 ft. and extend underground for a distance of 300 ft. to the east 18-in. header. All underground parts of the crossing were coated with coal tar enamel, and were made secure by river clamps and anchors as protection against periods of high water.

As a means of control, a dual installation of plug valves was made, one electrically controlled, the other hydraulically controlled. Identical instal-

General map of United Gas Pipe Line Company's new line



A LITTLE THING TO LOOK FOR BUT A BIG THING TO FIND



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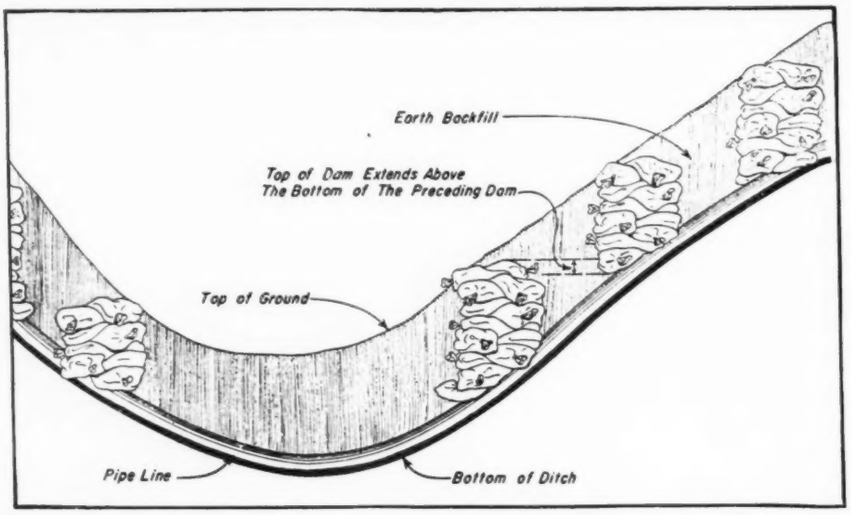

Sketch showing the manner in which the ditch was rip-rapped on abrupt slopes to protect the backfill

lation were made on each of the 14-in. lines, but for the sake of simplicity a description of but one system will be given. At both the east and west 18-in. headers a valve was installed in the line and adjacent to it on the river side was placed a 6-in. blowoff valve. The latter valves are operated by reversible motors and are connected to relays installed in a small steel building situated at each header. The motors are connected to a control cabinet in the toll house at the east end of the bridge. In the event of an emergency, the toll-house attendant can break a glass panel and push a button that actuates the interlocking controls. This action starts-up the motors that operate the valves, and they continue running until the two 14-in. valves are closed and the 6-in. blowoff valves are opened, whereupon limit switches cut-off the motors.

The control cabinet contains another compartment, accessible only to certain employees of the United Gas Pipe Line Company. In it are buttons that will cause the motors to reverse, opening the 14-in. valves and closing the 6-in. blowoff valves. In the small control house at each header are other switches that can be operated independently to open and close the valves.

An added safeguard for controlling the lines is provided by two 14-in. plug valves and a single 6-in. blowoff valve installed on the bridge proper. The 14-in. valves are placed near each portal and the 6-in. valve is in the center of the bridge. These valves are controlled in a manner similar to the electrically-controlled valves except that fluid lines transmit pressure to control cylinders at the valves, making possible their rapid operation by merely pressing an actuating mechanism in the toll house.

Equipment for the Jackson compressor station was moved from the Richland station in Louisiana. Twelve 160-hp. vertical compressor units, having 14¾-in. by 16-in. 3-cylinder engines and 8½-in. by 16-in. compressor cylinders, were installed. The station is arranged to take suction either from the new 18-in. line or the line from the Jackson field. The suction header, which is 20 in., and the discharge header, which is 16 in., both loop the station so that the load to the compressors can be equalized at all points. The headers are in concrete pits. Suction pressure varies but usually is about 250 lb.; discharge pressure is approximately 400 lb.

A 4-ft. by 14-ft. scrubber is placed on the line from the Jackson field and two 4-ft. by 17-ft. scrubbers on the new line.

Gas, after leaving the compressor units, passes through coolers in the base of the atmospheric-type cooling tower before entering the main line. When operating at capacity the gas leaves the tower at a temperature of approximately 100°F.

A centrifuge is provided for reconditioning engine lubricating oil. The arrangement is such that the oil can be run continuously or in batch.

Electric power used in operating the station is purchased. As a standby unit a generator set formerly used at Richland station has been installed.

Water supply is from two water wells drilled to a depth of approximately 600 ft. The wells are flowed by gas-lift and the water passes through two gas-oil separators before entering a settling basin. The gas is discharged to the fuel lines. Water is pumped from the settling basin to the cooling tower from where it circulates to the compressor engines, to a hot well, and back to the cooling tower. From the settling basin, water is also pumped to two overhead tanks. One, of 25,000-gal. capacity, is for surge, and the other, of 5000-gal. capacity, is for domestic use.

Gas from the Sligo, Sibley, and Lake Bistineau fields enters the main gathering lines from the wells at a pressure of about 800 lb. The 18-in. trunk line is operated at a pressure of 500 lb.

The general contractor for laying the line was Brown and Root, Houston, Texas.

The Mississippi River crossing at Vicksburg while under construction

Graphic Method Facilitates Gas Pipe Line Flow Calculations

Pressures at intermediate delivery or intake points are readily determined when volumes are known

By G. H. McKAY

Engineer, Arkansas Natural Gas Corporation

DURING the initial discussions that precede the design of virtually every gas transportation system, a "quick" answer concerning line capacity may be desired in each of several proposed sets of flow conditions. Particularly when numerous input and discharge connections are involved, extended calculations for each combination may consume more time than is warranted for merely discussion purposes. As an aid to the engineer who must make these calculations, a series of charts may be prepared that will expedite the work materially.

As a preliminary step in the preparation of the charts, Weymouth's generally accepted formula for the flow of gas through long pipe lines was studied by the writer to determine the type of curve it represents.

Weymouth's formula is as follows:

$$Q=18.062\,\frac{T_0}{P_0}\left[\frac{(P_1^2-P_2^2)\,d^{5\frac{1}{3}}}{GTL}\right]^{\frac{1}{2}} \quad (1)$$

Q = volume of gas discharged, cu. ft. per hr., based on P_0 and T_0.
T_0 = absolute temperature of gas under measurement conditions.
P_0 = pressure base of measurement, lb. per sq. in. abs.
P_1 = initial pressure, lb. per sq. in. abs.
P_2 = final pressure, lb. per sq. in. abs.
d = inside diameter of pipe, in.
G = specific gravity of flowing gas, air = 1.0.
T = absolute temperature of flowing gas.
L = length of line, mi.

Assuming standard conditions of

T_0 = 60°F. or 520° absolute
P_0 = 14.4 lb. per sq. in. absolute
T = 60°F. or 520° absolute
G = 0.60

The formula can be written

$$Q=36.9d^{8/3}\sqrt{\frac{P_1^2-P_2^2}{L}} \quad . \quad . \quad . \quad (2)$$

When Q is the volume discharged in 24 hr., formula (2) can be written as follows:

$$Q=886d^{8/3}\sqrt{\frac{P_1^2-P_2^2}{L}} \quad . \quad . \quad . \quad (3)$$

When Q is the volume discharged in 24 hr., formula (1) can be written as follows:

$$Q=433.49\,\frac{T_0}{P_0}\left[\frac{(P_1^2-P_2^2)\,d^{5\frac{1}{3}}}{GTL}\right]^{\frac{1}{2}} \quad (4)$$

G. H. McKAY

received a bachelor's degree in civil engineering from Mississippi State College, State College, Mississippi, in 1930—After graduation, he was employed by the Arkansas Natural Gas Corporation, and placed in its Junior Engineer Training Course where for two years he received field and office training in the various phases of the company's operations in the gas production, gas transportation, gas compression, gas distribution, oil production, oil transportation, and natural gasoline departments—At the end of this period, seven years ago, he was placed on the general engineering staff of the Arkansas Natural Gas Corporation.

For different pressure bases and different standard conditions the constant varies.

The formula and its curve as plotted on different types of graph paper were first studied. A linear or first-degree equation, represented by a straight line, is the easiest to plot accurately; therefore, Weymouth's formula plotted as a straight line would result in the best chart. The formula for a straight line is

$$Y = nX + K$$

in which X and Y are the variables.

When the size (inside diameter) of the pipe and the length of the line are given, the only variable for different flow conditions is the difference in the absolute pressures squared. Rearranging equation (3):

$$Q=886\left(\frac{\sqrt[3]{d^8}}{\sqrt{L}}\right)\left(P_1^2-P_2^2\right)^{\frac{1}{2}} \quad (5)$$

To convert the formula into the linear or straight-line form, let

$Y=Q$ (this is a variable)

$A=886\,\frac{\sqrt[3]{d^8}}{\sqrt{L}}$ (this is a constant when d and L are known)

$X^n=(P_1^2-P_2^2)^{\frac{1}{2}}$ (this is a variable)

Then the equation becomes

$$Y=AX^n \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

This equation would not be a straight line plotted on rectangular coördinate paper except when $n = 1$. To plot $Y = AX^n$ as a straight line, the log is taken of both sides

$$\log Y = \log A + n \log X \quad . \quad . \quad . \quad . \quad (7)$$

As equation (7) is now in the form $Y = nX + K$ it may be plotted as a straight line.

When a point (X, Y) is plotted on logarithmic paper, the linear distance from the origin to the projection of the point on the horizontal or X axis is the log of X, and the linear distance from the origin to the projection of the point on the vertical or Y axis is the log of Y.

The slope n of the straight line in

TABLE I

Point	Section	Length of line, mi.	M. cu. ft. per hr.		
			Supply	Delivery	Flow
1			2500		
	1	15.9			2500
2				1500	
	2	20.1			1000
3			1000		
	3	11.1			2000
4			1000		
	4	9.7			3000
5				1000	
	5	23.2			2000
6			1500		
	6	11.0			3500
7			1500		
	7	29.6			5000
8				5000	

equation (7) is the exponent of the difference of the absolute pressures squared in equation (5). The slope of the line is constant, therefore, for any length or any flow condition. Any change in d, the diameter and/or L, the length of line, only changes the position of the line on the chart and not its slope.

Applying the above to a specific problem: Given: Pipe line size—20 in. Minimum pressure at any point on the line = 125 lb. per sq. in. gauge. Maximum pressure at any point on the line = 450 lb. per sq. in. gauge.

Gas supply from five different fields:
Field 1 = 2,500,000 cu. ft. per hr.
Field 2 = 1,000,000 cu. ft. per hr.
Field 3 = 1,000,000 cu. ft. per hr.
Field 4 = 1,500,000 cu. ft. per hr.
Field 5 = 1,500,000 cu. ft. per hr.
Gas delivery at three different points:
Point No. 1 = 1,500,000 cu. ft. per hr.
Point No. 2 = 1,000,000 cu. ft. per hr.
Point No. 3 = 5,000,000 cu. ft. per hr.

The accompanying sketch shows the distances between these supply and delivery points. (Fig. 1).

To find:

Pressure at each point under above conditions and capacity of each section for different pressure conditions.

Solution:

First solve the problem using the assumed flow conditions. After the graphs or charts have been made, the volumes or other flow conditions can be changed and the pressures and capacities under the changed conditions can be easily calculated.

The information given may be tabulated as in Table 1.

Due to the fact that the graphs of all the sections of the line will have the same slope, only one section was studied thoroughly and its capacity under several different flow conditions was calculated. The results were plotted on log-log paper; for each other section only two or three flows were calculated and lines parallel to the first were drawn through these points.

When the volume of gas per hr. through each section of the pipe line is known, the difference in the squares of the absolute pressures can be easily ascertained from the chart. The difference in the squares of the absolute pressures is added to the square of the minimum or delivery absolute pressure at the end of the line to obtain the required initial absolute pressure squared.

Use of Chart:

On Chart 1, follow the flow of 2,500,000 cu. ft. per hr. horizontally until it crosses with Section 1 line, then follow this vertically to the scale for the difference in pressures squared and record 8200. Then follow the flow of 1,000,000 cu. ft. per hr. horizontally to Section 2 line, then vertically down and record the difference in the pressures squared of 1680. Then follow the flow of 2,000,000 cu. ft. per hr. horizontally to Section 3 line, then vertically down and record the difference in the pressures squared of 3700.

Fig. 1

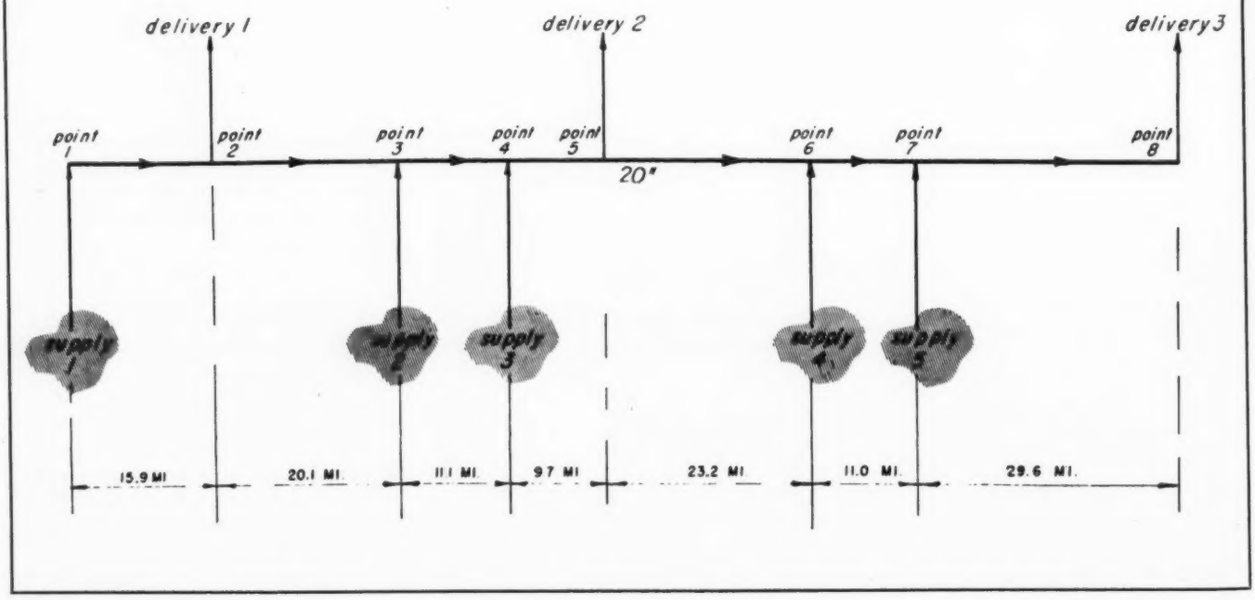

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Fig. 481—JARECKI "Extreme Service" Bronze Gate Valve, for Refinery and Natural Gasoline Plant service; 200 lbs. S.W.P., 400 lbs. O.W.G.

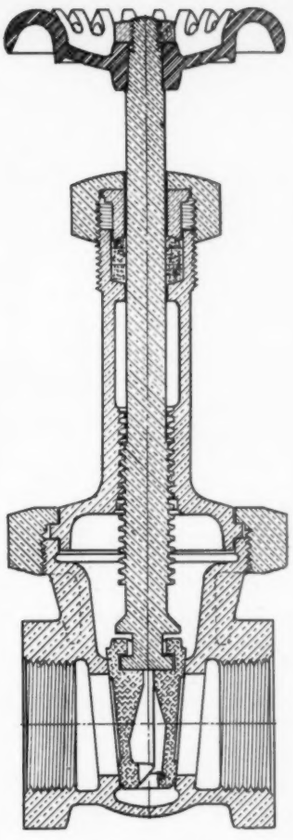

Fig. 481—Cross Sectional Drawing

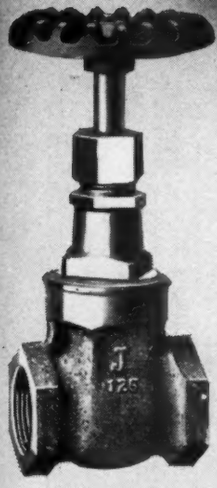

Fig. 450
Standard Bronze
Gate Valve

Fig. 426
Heavy Standard
Bronze Check Valve

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Fig. 414
Heavy Standard
Bronze Globe Valve

Fig. 424
Bronze Regrinding
Swing Check Valve

TABLE 2

Point	Section	$(P_1^2—P_2^2)$	Absolute pressures squared	Gauge pressure, lb. per sq. in.
1			119,712	332
	1	8,200		
2			111,512	320
	2	1,680		
3			109,832	317
	3	3,700		
4			106,132	311
	4	7,150		
5			98,982	300
	5	7,650		
6			91,332	288
	6	11,100		
7			80,232	269
	7	60,800		
8			19,432	125

Likewise follow the flow of 3,000,000 cu. ft. per hr. horizontally to the line for Section 4, then vertically and record the reading for difference in the pressures squared of 7150. Again follow the flow of 2,000,000 cu. ft. per hr. horizontally to the line for Section 5 and then vertically and record the difference in the pressures squared of 7650. Then follow the flow of 3,500,000 cu. ft. per hr. horizontally to the line for Section 6, then vertically and record the difference in the pressures squared of 11,100. Follow the flow of 5,000,000 cu. ft. per hr. horizontally to the line for Section 7, then vertically and record the difference in the pressures squared of 60,800.

The differences in the pressures squared may be tabulated as in Table 2. Beginning by adding the minimum pressure squared (at Point 8), pressures at the other points along the line can be found.

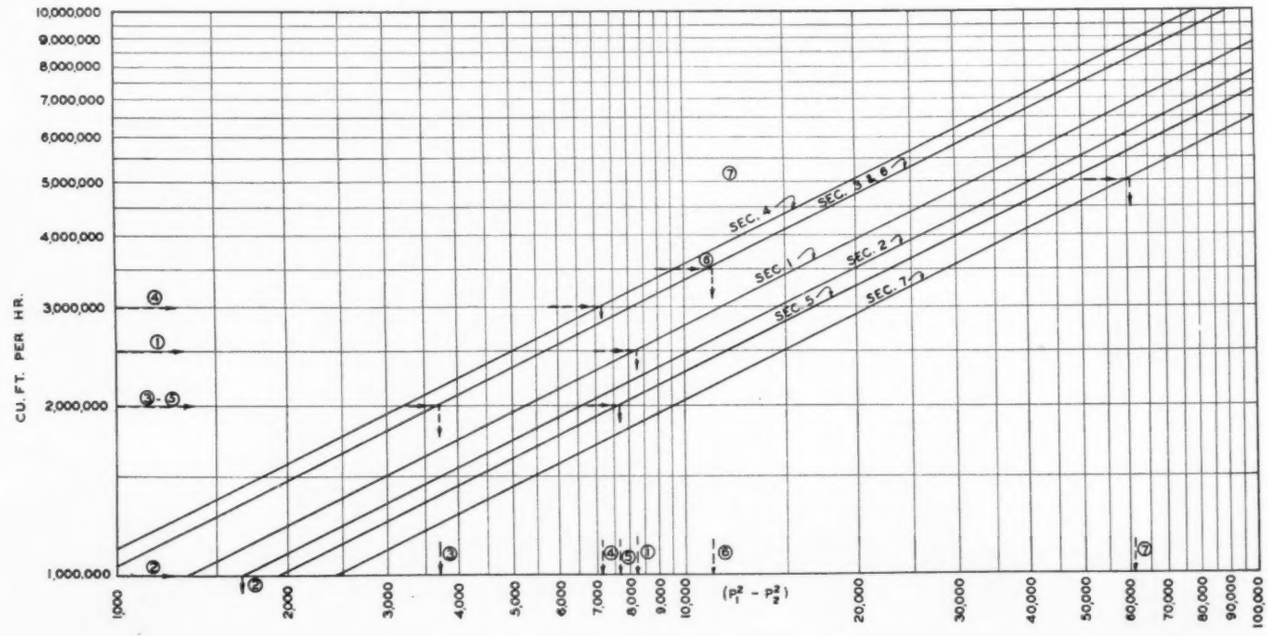
Using the flow as set up in Table 3 and following directions as shown in the first problem, the pressures along the line can be found as indicated in Table 3.

Pipe lines do not operate at full capacity or with 100 percent load factor except in rare instances. The capacities as calculated in the above problem, therefore, are for peak hour conditions. The delivery for a day would be the peak delivery per hour multiplied by the number of hours in a day if it were not for the load factor. The hourly load factor is the percent the average hour is to the peak hour. If operating conditions were perfect; that is, if the maximum delivery was exactly the same as the maximum input, the peak hour capacity would equal the theoretical capacity. If the average delivery per hour, therefore, which is obtained from experience, or from known operating data, is divided by the peak (theoretical) capacity per hour, the load factor is obtained.

TABLE 3

Point	Section	Supply	Delivery	Flow	$(P_1^2—P_2^2)$	Absolute pressures squared	Gauge pressure, lb.persq.in.
1		3,500				170,502	398
	1			3,500	16,200		
2			1,500			154,302	379
	2			2,000	6,620		
3		500				147,682	370
	3			2,500	5,700		
4		2,500				141,982	363
	4			5,000	19,750		
5			1,500			122,232	336
	5			3,500	23,500		
6		1,000				98,732	300
	6			4,500	18,500		
7		500				80,232	269
	7			5,000	60,800		
8			5,000			19,432	125

Chart 1



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Presence of certain salts results in formation of scale, foaming and priming, pitting, caustic embrittlement, and other ills—chemical analysis will determine the water-treatment required

By

ROY W. MACHEN,

Superintendent, Hamman Exploration Company

MOST waters used in steam power plants are "hard"; that is, they contain enough dissolved calcium or magnesium compounds to cause harmful or objectionable results. Waters taken from rivers, lakes, ponds, etc., usually carry mud or silt in suspension. The impurities present in a water may be classified generally as those either in suspension or in solution.

Pure Water

Water may be found in any one of three forms, depending on the pressure and temperature. At 32°F. and atmospheric pressure water becomes a solid. When the temperature is raised to 212°F. at atmospheric pressure water becomes a gas, or steam. At atmospheric pressure and when the temperature is between 32 and 212°F. water is a liquid. Its greatest density is at 39.2°F. and one cu. ft. of pure water at this temperature weighs 62.425 lb.

Pure water has neither acid nor alkaline properties and is neutral in reaction.

Natural Waters

When water vapor condenses and falls to the earth as rain, there is a certain amount of oxygen, carbon dioxide, nitrogen, and other gases dissolved in it that were taken from the air. A portion of the rain sinks deeply into the ground to find a level at the nearest water table. As it passes through the rocky crust of the earth it dissolves the more soluble substances contained in the material over which it passes to form in major part carbonates of lime, magnesia, iron, and alkalies. The properties of the impurities found in any natural water and their proportions depend on the nature of the layers of rock and the overlying earth through or over which the water has passed.

Natural waters, even when they contain what is considered large quantities of solids, are very weak solutions of salts. An extremely hard water that contains 25 grains of solids per gal. is only approximately a 0.04 percent solution.

ROY W. MACHEN

received a bachelor's degree from Oklahoma City University in 1927—Employed for six and one-half years by the Peppers Gasoline Company as refinery clerk, refinery and gasoline plant chemist, and gas engineer—The last six years have been spent in the service of various independent refining companies as gas engineer, operator in high-pressure gasoline plants, refinery construction engineer, and superintendent of refinery operations—He is a registered petroleum and natural gas engineer—Recently he was promoted to superintendent by the Hamman Exploration Company.

Suspended Impurities

Suspended matter may be removed from boiler feedwater in one of three ways: settling, filtration, or coagulation. The latter method is favored because of the rapidity of action between the suspended materials and the coagulating chemical. Even when the filtering method is used it is found to be of advantage in many cases to use a coagulant as an aid.

Impurities in Solution

Water is employed in the natural gasoline plant in two major operations: to feed boilers, and for cooling and condensation.

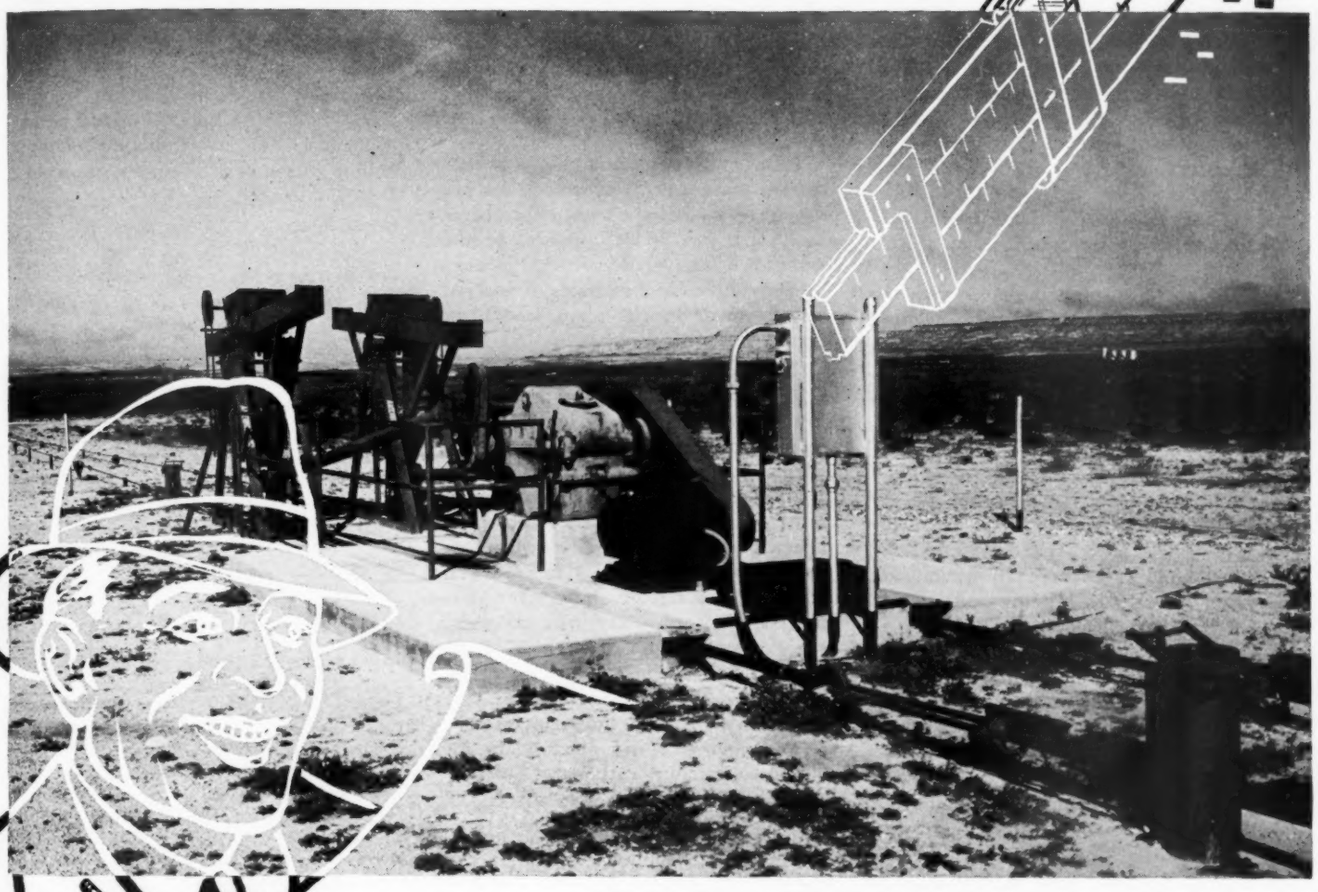
When water from any source is used for the generation of steam, it is subjected to the action of high temperature and pressure. The quantity of incrusting solids that the water can hold in solution depends on two factors: the amount of certain dissolved gases present, and the temperature of the water.

The mineral salts contained in solution consist of "incrusting or total hardness solids" and "alkaline salts". The former consists of carbonates of calcium and magnesium and sulphates of calcium and magnesium. The latter class of solids is composed of sodium chloride, sodium sulphate, and sodium carbonate.

As the water is evaporated in the boiler to form steam, the incrusting salts that were in solution remain behind. The gases held in solution are expelled by the heating of the water.

Calcium carbonate will be dissolved by water that contains carbon dioxide in solution to form calcium bicarbonate. When the carbon dioxide is expelled by heating the water in the boiler, calcium bicarbonate becomes calcium carbonate and precipitates. Magnesium carbonate is dissolved and magnesium bicarbonate is deposited in the same manner as is calcium carbonate. The principal characteristic of the carbonate salts is their precipitation when water is boiled at atmospheric pressure to form a soft scale or sludge, which results in a dirty boiler and

Why ENGINEERS PREFER IT . . .



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foaming. The water hardness that is diminished by this precipitation is called temporary hardness.

The hardness that remains after boiling is principally due to the presence of calcium and magnesium sulphates, chlorides, nitrates, and residual carbonates. This remaining hardness is called permanent hardness, and the sulphate salts characterized by this hardness are precipitated when water is boiled at about 60-lb. pressure to form a hard scale. The concentration of these salts until the so-called "critical point" or saturation point has been reached is necessary before precipitation will begin.

Calcium sulphate when concentrated in solution will crystallize as a hard scale.

Magnesium sulphate reacts with the calcium bicarbonates to form calcium sulphate, which is then deposited as a hard scale.

If a water containing calcium sulphate is treated with sodium carbonate, the resulting calcium carbonate will be precipitated as a soft sludge that can be blown from the boiler and the sodium sulphate will remain in solution.

Alkaline salts remain in solution after water has been evaporated to form steam. All potassium and sodium salts are very soluble in water, but they do not form scale. Concentration of these materials causes foaming or priming and periodic or continuous blowdown is the means used to hold concentration below that which must be attained before foaming and priming become detrimental to efficient boiler operation.

The changes that occur due to chemical reaction between the various salts cause, in addition to scaling, foaming and priming, also pitting, corrosion, and caustic embrittlement.

Magnesium chloride decomposes under heat to form a dilute hydrochloric acid that is very corrosive, and magnesium hydroxide.

Sodium nitrate is considered a potential corrosive agent if present in an appreciable amount, especially as decomposition takes place in the presence of other salts.

Sodium chloride is inert in the boiler by itself; however, if magnesium sulphate is present, it becomes extremely corrosive.

Carbon dioxide, if liberated in the boiler by heat, has a tendency to cause pitting and corrosion.

Oxygen is a stimulating factor in corrosion.

Magnesium nitrate in the presence of calcium carbonate at ordinary boiler pressures and temperatures will form calcium nitrate and magnesium carbonate.

Calcium nitrate is generally believed to have a corrosive action in boiler waters because of its decomposition to form nitrates of iron.

Sodium sulphate under ordinary conditions is an inert salt. It is used, however, in many instances to treat boiler waters high in carbonate content for the purpose of converting a water having a low sulphate ratio into one having a high sulphate ratio.

Boiler Water Treatment

In order to determine the best corrective treatment, a chemical analysis should be made by a competent chemist. After this "pilot" analysis of the water has been made, periodic checks by the simple rapid methods of analysis can be made in the plant laboratory for purposes of control.

The treatment necessary to remove scale-forming substances and corrosive materials from the boiler feedwater will be determined entirely by the chemical analysis. If this analysis shows a combination of incrusting solids that must be removed, the most common chemicals used for that purpose are lime (calcium hydroxide) and soda ash (sodium carbonate). Quite often it is necessary to use only one of these chemicals but more often it is found that a combination of the two is desirable. Such incrusting solids as calcium and magnesium bicarbonates, sulphates, chlorides, and nitrates are reduced to calcium carbonate and soluble neutral salts that later will be removed by boiler blowdown.

There are two methods of treating water with lime and soda ash. The cold method may be either of the intermittent or continuous type, whereas the hot processing method is of the continuous type only.

As the chemical reactions and precipitation are more rapid when the water is hot the advantages of the hot processing methods are obvious. Although authorities differ regarding the speed of reaction at higher temperatures, it has been proved that the calcium and magnesium salts are reduced more in ten minutes at 210°F. than in five hours at 50°F. It has also been found that precipitation is about four times as rapid at 210°F. as at 68°F. The principal advantage of the hot process type over the cold process method is the venting of the dissolved oxygen and carbon dioxide, which would cause corrosion if their elimination occurred in the boiler.

Other external methods of water treatment are by the use of caustic soda, zeolite type softeners, and sodium phosphate.

The treatment of numerous natural waters for boiler feed purposes is possible without the construction of an expensive treating plant. When such a water is found, the cheapest as well as the best method is internal treatment. There are four major purposes for conditioning boiler water internally: scale prevention, corrosion prevention, protection against embrittlement, and reduction of the tendencies toward foaming and priming.

For the prevention of scale by internal treatment, three principal types of chemicals are used: organic colloids, sodium aluminate, and phosphates.

The reduction of the priming and foaming tendencies of a boiler water is accomplished by the internal use of a coagulant. Sodium aluminate is perhaps the most widely used coagulant and in most cases is found to be satisfactory.

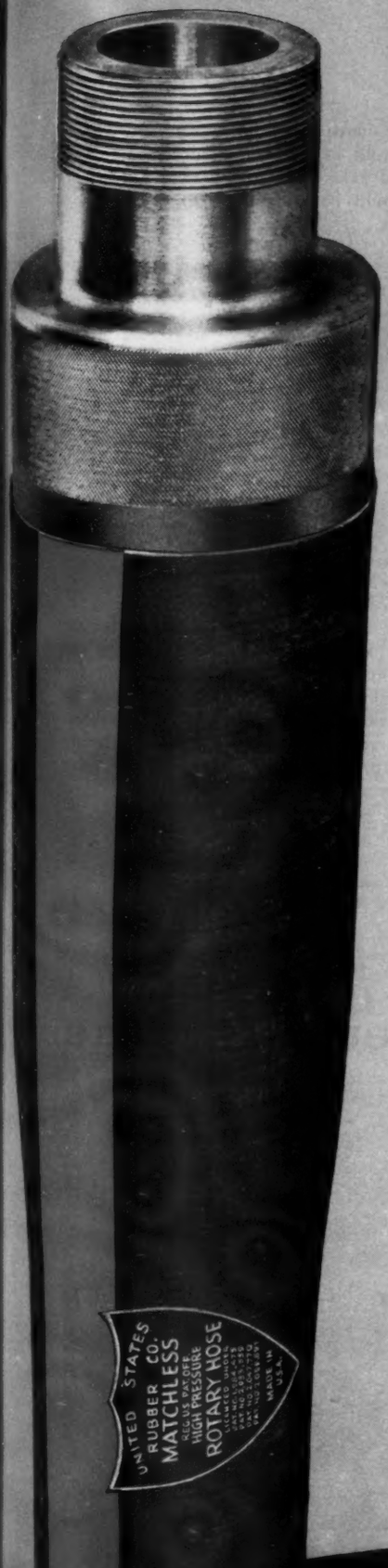
Corrosion can be held at a minimum by the feeding of hot water to the boiler. In other words, the feedwater being preheated vents the dissolved oxygen and carbon dioxide, two of the worst offenders. The pH of the water is usually the most important characteristic to be watched. This is especially true when there is free acidity or alkalinity in the boiler feed. The simplest method of control for pH is by the addition of acid or alkali, whichever is required, to hold the correct value.

The prevention of embrittlement is obtained in various ways; however, the final result is substantially the same —the maintaining of a definite sulphate-carbonate ratio as recommended in the A.S.M.E. Boiler Code, Section 7, Par. CA-5. The recommended ratios are:

	Sodium sulphate		Sodium carbonate
For pressures to 150 lb.	1	:	1
For pressures 150 to 250 lb.	2	:	1
For pressures greater than 250 lb.	3	:	1

The ratio obtained in practice must not fall below that recommended; however, any ratio above that indicated for the operating pressure is safe. The final answer concerning just what "caustic embrittlement" is has not yet been found. Not many have seen actual cases of embrittlement and for that reason are inclined to doubt its existence. There have been few boiler failures directly traceable to embrittlement but even one such failure is to be avoided if possible.

The maintenance of the sulphate-carbonate ratio may not be considered scientific by everyone, but it is con-



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Service Beyond Price and Specifications

sidered by many that the recommended ratios will, if adhered to, help prevent boiler failures.

The maintenance of the sulphate-carbonate ratio may be accomplished in one of two ways: by the addition of sulphates or by the decrease of alkalinity.

The addition of sodium sulphate is perhaps the most common method used to increase the sulphates. The use of this salt results in only a protective action. The addition of a phosphate results in a positive action, because the alkalinity is reduced and the unwanted constituent is removed. Adding sulphuric acid or sodium acid sulphate results in a simultaneous reduction of alkalinity and increase in sulphate content.

Water Analyses

There are two methods of expressing the quantity of substances present in a given sample of water. Most industrial water analyses are expressed in grains per gal., whereas there are a number of laboratories that express quantities in both grains per gal. and parts per million. The following conversion factors will be found helpful when it is desired to change an analysis from one form to the other:

1 gr. per U. S. gal.	=	17.1 parts per million	= 1.71 parts per 100,000
1 part per million	=	0.058 gr. per U. S. gal.	= 0.10 parts per 100,000
1 part per 100,000	=	0.585 gr. per U. S. gal.	= 10.0 parts per million
grams per liter × 58.4	=	grains per U. S. gal.	

Recording Test Results

P = phenolphthalein alkalinity (as calcium carbonate)
M = methyl orange alkalinity (as calcium carbonate)
H = soap hardness (as calcium carbonate)

A = (excess alkalinity) M-H
B = (excess hydroxide) 2P-M
C = (excess carbonate) A-B

As all the above are in terms of calcium carbonate, to correct the results to the alkalies as they are actually present in the water the following factors should be applied:

Calcium carbonate × 0.8 = sodium hydroxide

Calcium carbonate × 1.06 = sodium carbonate

The sulphate test should control the amount of corrective to be used for inhibition of intercrystalline cracking or embrittlement, the sulphate-carbonate ratio being held above the limits recommended by the A.S.M.E. Boiler Operating Code.

Quantities of corrective required should be controlled on the hardness and alkalinity tests and blowdown should be controlled on the chloride test.

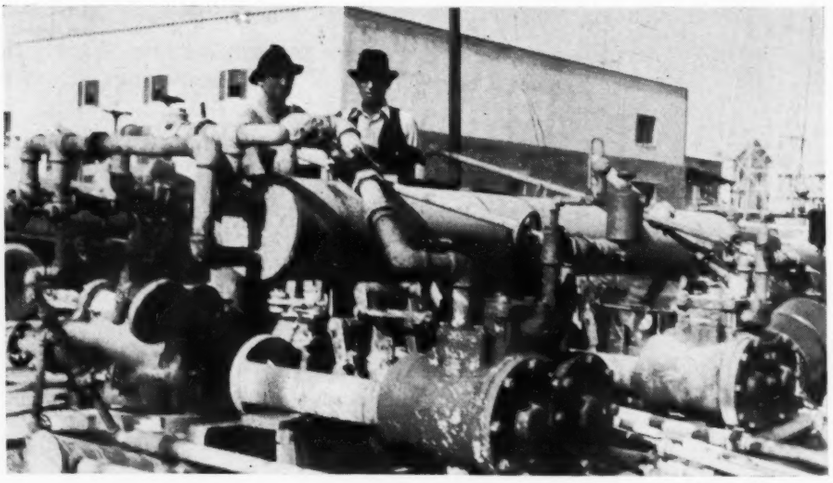
P 422.333

Compact Feedwater Heater Set-up for the Drilling Rig

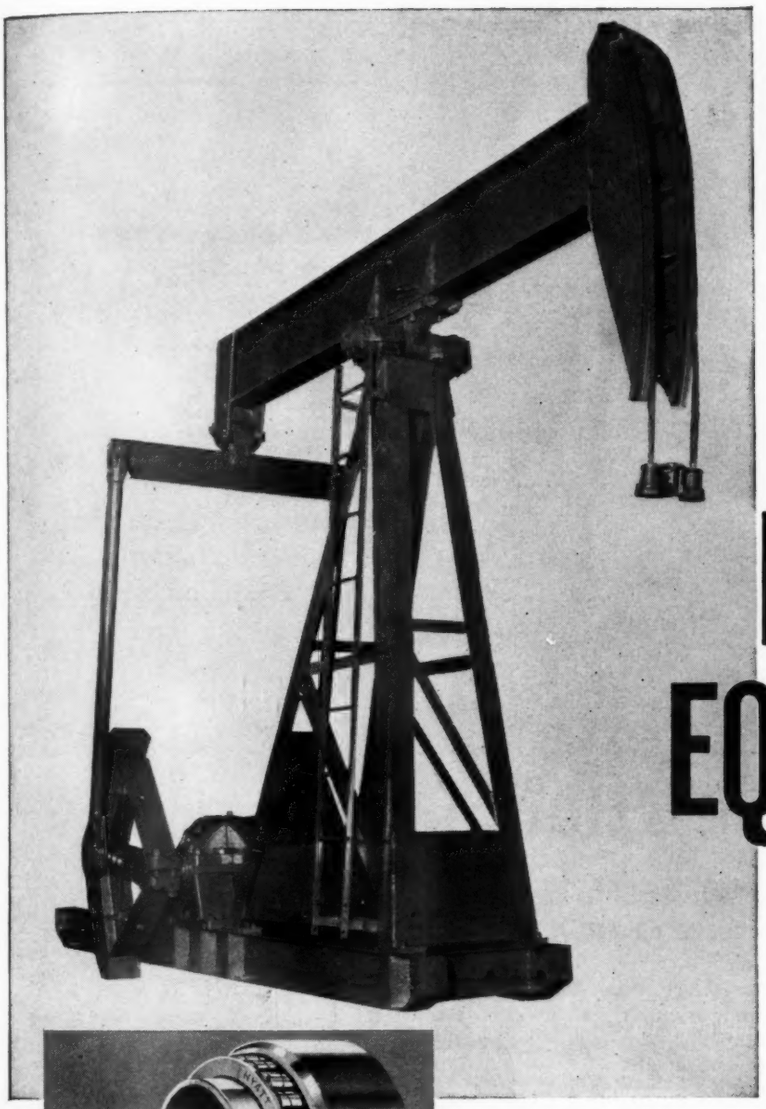
By
CHAS. C. LYNDE

COMPACTNESS and portability are of prime importance around the drilling rig, and any rearrangement of units that will contribute to these factors, and at the same time reduce heat loss, is important. One drilling contractor gains all three goals when he mounts the feedwater heater for his boiler-feed pumps on brackets set-up on the skip carrying the twin pump units. The heater, of the usual pipe type, nests closely between the steam and water ends of the pumps, affording the minimum of piping for connecting both ends to it. Short leads carry pump exhaust steam into the chamber, and equally short lines convey the hot water to the water end, providing a positive gravity displacement into the pump to prevent drawing a vacuum and possibly flashing steam.

The entire unit may be loaded on a truck for transfer to a new location with no more space requirement than the usual pump setting, saving a truck, or at least a portion of a truck load usually set aside for transporting the feed-water unit.

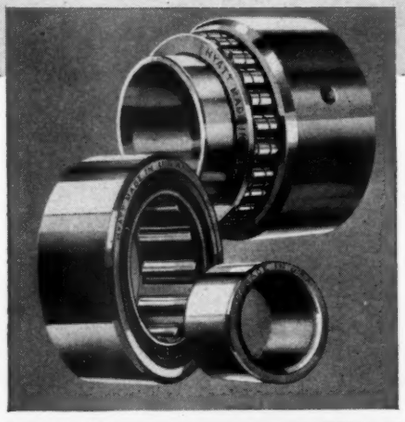


Nested snugly between steam and water ends of this boiler-feed unit, the feedwater heater provides shortest steam and water travel, and is compactly assembled for frequent shifts



This EMSCO TWIN CRANK PORTABLE PUMPING UNIT is a typical example of how long life is built into oil field machinery with Hyatt Roller Bearings.

LONGER EQUIPMENT LIFE



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On and on it goes . . . equipment of every description . . . a symphony of mechanical smoothness . . . with gears, shafts, and wheels turning silently, accurately, effortlessly on Hyatt Roller Bearings. Long lived, carefree bearings that serve the petroleum industry so faithfully year after year . . . that help leading builders of oil field equipment to better serve operators. Hyatt Bearings Division, General Motors Sales Corporation, Harrison, New Jersey; Detroit, Chicago, Pittsburgh and San Francisco.

HYATT ROLLER BEARINGS

Fig. 1

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

By
BILL DAVIS
Mechanical Engineer,
American Liberty Pipe
Line Company

Pipe-Line Gauger's Car Equipped For Efficiency

Originality and forethought in arrangement places all instruments readily at hand

OIL-FIELD workers are renowned for their ability to turn unusual and clever ideas into workable, everyday "gadgets". In the field of production, roughnecks and roustabouts alike use their spare time fashioning materials common to their work, such as pipe and sucker rods, into devices that help them do their respective jobs quicker and safer.

The pipe-line department, too, has its problems that it must solve from day to day. Gaugers and pumpers are always on the lookout for a more efficient approach to the various problems as they arise.

Just how well one gauger in the East Texas field has solved his particular problem may be seen in the accompanying photographs.

Fig. 1 shows the rear end of the gauger's car with turtle lid open. The interior is painted with aluminum paint and presents a clean and well-kept appearance. Any oil spilled can be instantly detected against this light background and wiped up. In like manner, corners are kept free from dirt because the light paint emphasizes its presence.

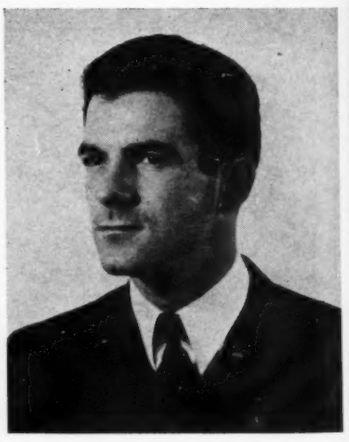
At the extreme left is a device made on the order of a grocery store ticket file for keeping tank seals together and in their numerical order. This is fashioned from coat-hanger wire and installed by bolting it to the inside of the car with the same bolt that holds the turtle lid support.

The short-handled shovel is held in place and prevented from sliding about the car by two U-shaped brackets that are bolted to the floor.

Mounted under the lid is a 30-candlepower headlight globe that is used when working at night. The globe is protected from breaking by a wire cage constructed from hard-drawn wire cut, bent, and soldered into the proper shape. A wall switch situated on the right-hand side of the car operates the light.

In the foreground can be seen the tool and instrument tray bolted to the deck floor by ⅛-in. by ½-in. strap iron. Immediately behind the tray is the electric centrifuge and the hot water oil heater.

Fig. 2 shows a close-up of this interesting arrangement. The centrifuge is made from a Model-A Ford starter rewound to give a minimum speed of 1000 r.p.m. A standard two-tube centrifuge mounting is welded to the shaft



BILL DAVIS

was born in Fort Worth, Texas, in 1915—Graduated from Texas Technological College, Lubbock, Texas, in 1937 with a degree in mechanical engineering—Became associated with oil industry by joining staff of E. F. Moran Drilling Company—Later was employed by the Continental Oil Company at Hobbs, New Mexico —Early part of 1938 he joined the engineering staff of the American Liberty Pipe Line Company as mechanical engineer.

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EXTREME LINE CASING

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STREAMLINED FOR SPEED

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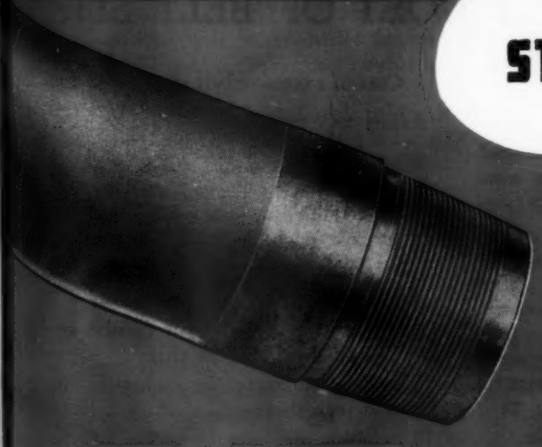
EASY TO STAB

FOR RECORD WELLS OR STANDARD DEPTH OPERATION



The hit of the oil fields since 1935, STANDARD SEAMLESS EXTREME LINE CASING continues to emblazon its name and fame for outstanding, all-around performance among drilling men everywhere.

Operators marvel at its high joint strength and leak resistance against extreme tensile strains and high pressures . . . makeup men like the remarkably easy stabbing and reduced time required in spinning and tonging . . . experienced derrick floor crews enthuse as the smooth, streamlined joints are run down the hole with record speed. "Extreme Line" can be broken out and rerun without galling or other injuries and will be tight after repeated makeups.

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Fig. 2

Fig. 3

of the rewound starter, which operates from the regular battery installed in the car. The entire assembly is bolted firmly to the deck in a permanent mounting. A knife switch for operating the centrifuge is mounted on the side of the tray within easy reach of the gauger.

The heater for warming the oil before it is centrifuged is constructed from 16-gauge sheet iron fusion-welded into a box 4 in. by 6 in. by 6 in. The top has two places for test-tube holders made from thin copper tubing of sufficient diameter to receive the test tubes in a loose fit. The bottoms of the tubes are blanked-off to make the box watertight. To circulate hot water through the box there are two ⅜-in. connections welded to the side for hot water inlet and outlet hose connections. Regular water-heater hose is used to carry hot water from a tapped connection on the engine block to the oil heater. No valves or thermostats are necessary, and the hot water circulates through the heater whenever the engine is running.

In the tray may be seen compartments for a thermometer case, oil thief, grease gun, and tools for servicing the engine at gathering line pump stations. There is also space for a safety flashlight, a one-gallon can of gasoline for priming pump engines, and a quart-size squirt-can that contains kerosine for cleaning thermometer, test tubes, and oil thief.

Fig. 3 shows how a notch was cut in the rear bumper guard for holding the oil thief upright while taking gravity readings, thus leaving the gauger's hands free to make preparations for shaking-out his oil sample.

It will also be noted that the oil thief has been tapped at the 6-in. and 8-in. levels and two brass pet cocks installed. This allows the gauger to determine the oil-water level without pouring from the top of the thief. As soon as the gauger is through with the sample, he pours it out, sprays the thief with kerosine from the squirt-can until it is clean, and then replaces it in its customary place in the tray.

P 094.6

FORMULA FOR COMPUTING YEARLY COST OF BELT SLIP

By W. F. SCHAPHORST

IT is well known by most oil men that all belts slip, but the *amount* of slip is not so well known and its determination has been more or less of a mystery.

So that any belt user can compute the slip of any drive, the following formula has been developed:

$$\text{Percentage slip} = 100 - \frac{100\,n\,(d+t)}{N(D+t)}$$

Where:

n = r.p.m. of the driven pulley.
N = r.p.m. of the driving pulley.
d = diameter in inches of the driven pulley.
D = diameter in inches of the driving pulley.
t = thickness of the belt in inches.

If a belt is transmitting full power, no matter how carefully it is attended, the above formula will disclose some amount of slip, due to the elasticity of the belt.

If the answer is 2 percent or less the belts may be considered in "good condition" as far as slip is concerned. But if the result is much greater than 2 percent, there is something wrong—the slip is excessive and perhaps entirely too expensive, consuming power, as it does, year in and year out.

To compute the cost of the excessive slip for one year, use this formula:

$$\text{Cost of excessive belt slip per year in dollars} = \left\{0.98 - \frac{n}{N}\,\frac{(d+t)}{(D+t)}\right\} PCHW$$

Where:

P = hp. delivered by the engine to the driving pulley.
C = cost in dollars of 1 hp. per hr.
H = running hours per day.
W = working days per year.

For V-belts the above formulas apply equally well except that:

d = pitch diameter in inches of the driven sheave.
D = pitch diameter in inches of the driving sheave.
t = zero.

Design, Construction, and Operating Features of World's Largest High-Pressure Condensate Recovery and Pressure Maintenance Plant

PETROLEUM ENGINEER EXCLUSIVE FEATURE

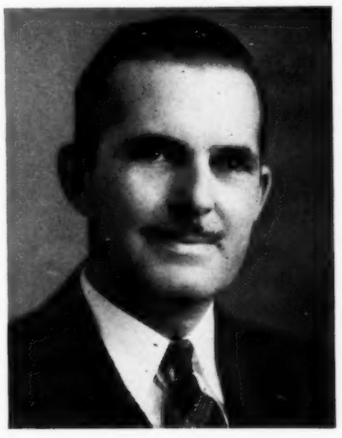
Designed to process 128,000,000 cu. ft. of gas per day, the plant will serve 12,000 acres. Gathering gas at 2000-lb. pressure, recovering gasoline at 1500-lb. pressure, and returning the stripped gas underground at 2500-lb. pressure, the project marks a significant trend toward high-pressure design

By RAY C. FISH
Sales Engineer,
The Stearns-Roger Manufacturing Company

THE Coastal Recycling Corporation's project for the recovery of condensate and for pressure maintenance in the Agua Dulce field, Nueces County, Texas, was developed by Clyde H. Alexander, John Sheerin, and Robert T. Wilson. Negotiations were begun in the fall of 1938 with the Union Producing Company, resulting in the execution of a contract in June, 1939, for processing gas from some 12,000 acres.

The preliminary investigation to determine the economics of the venture, the engineering design of the plant, and the actual construction work were all handled on a turnkey basis by The Stearns-Roger Manufacturing Company of Denver, Colorado, and their associates, Parkhill-Wade of Los Angeles, California. The contract was signed June 23, 1939. Field work was begun the latter part of August and the plant went into operation December 23. It is now operating at about two-thirds of its rated capacity and operations will be gradually increased as additional producing wells are drilled.

The project is designed to handle 128-130,000,000 cu. ft. of gas per day and is divided into three main divisions. The first is a high-pressure absorption unit designed to operate at a working pressure of 1500 lb. per sq. in. gauge. The second is a pressure maintenance plant designed to take the stripped gas from the processing unit and return it to the formation. The third is the system of piping for collecting the gas from the various producing wells, and for returning the gas to the input wells. The gas-gathering system is designed to operate at 2000 lb. per sq. in. working pressure and the input system at 2500 lb. per sq. in. working pressure. In addition to the three main divisions of the plant, there is a shipping pipe-line extension and the necessary pumping facilities for moving the plant products to the Corpus Christi harbor area.



RAY C. FISH

has occupied the position of sales engineer with the Stearns-Roger Manufacturing Company, Denver, Colorado, for the last ten years.

Plant Design

The absorption or processing plant incorporates several departures from the conventional. Direct-fired, radiant-type fat-oil heaters, designed for a continuous operating temperature of 550°F., are used. Motor fuel of end-point specification is fractionated in a high-pressure fractionating still to obtain maximum butane condensation. An atmospheric fractionating still is used to produce specification kerosine or distillate, at the same time controlling the initial and gravity of the absorption oil. An oil rectifying system has the dual purpose of keeping the lean absorption oil clean, and of a definite molecular weight, by controlling the end point. An emergency plant shut-down and venting system is included among the protective devices of the plant.

By referring to the colored flow sheet on page 123 the various stages of the operations in the processing plant and the equipment involved may be followed in logical order. The plant is situated strategically in about the center of the producing area. The wet gas entering the plant from the south area is metered by a 10-in. orifice-meter setting. Similar gas from the north area is metered by an 8-in. meter setting. At the point where these two streams of gas are combined, block valves are installed so that either the south or the north systems may be shut off from the plant if so desired. Pressure-reducing regulators near the block valves are set to maintain the gas entering the plant at a constant pressure of 1500 lb. per. sq. in. The gas flowing from the wells is at too high a temperature for satisfactory processing and is therefore led directly to atmospheric cooling sections installed in the base of the cooling tower. Here the temperature is reduced as much as possible with the tower cooling water.

From the cooling sections the gas is proportioned to the four high-pressure absorbers by means of indicating dial-type orifice meters installed on the outlet gas line from each absorber. Dry residue gas from the absorbers passes directly to the suction of the pressure-maintenance compressor units through two 10-in. meter settings.

The high-pressure absorbers are designed for operation at 1500 lb. per sq. in. Each contains 20 bubble-cap plates

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Testing of wells on actual producing basis to determine Capacity, Composition, Quantity and Quality of recoverable products, including Field Work and Complete Laboratory analyses;

Preparing an engineering report covering the economics of the project;

Designing and Constructing the entire installation on a complete turn-key basis . . .

Selecting and purchasing all equipment and materials;

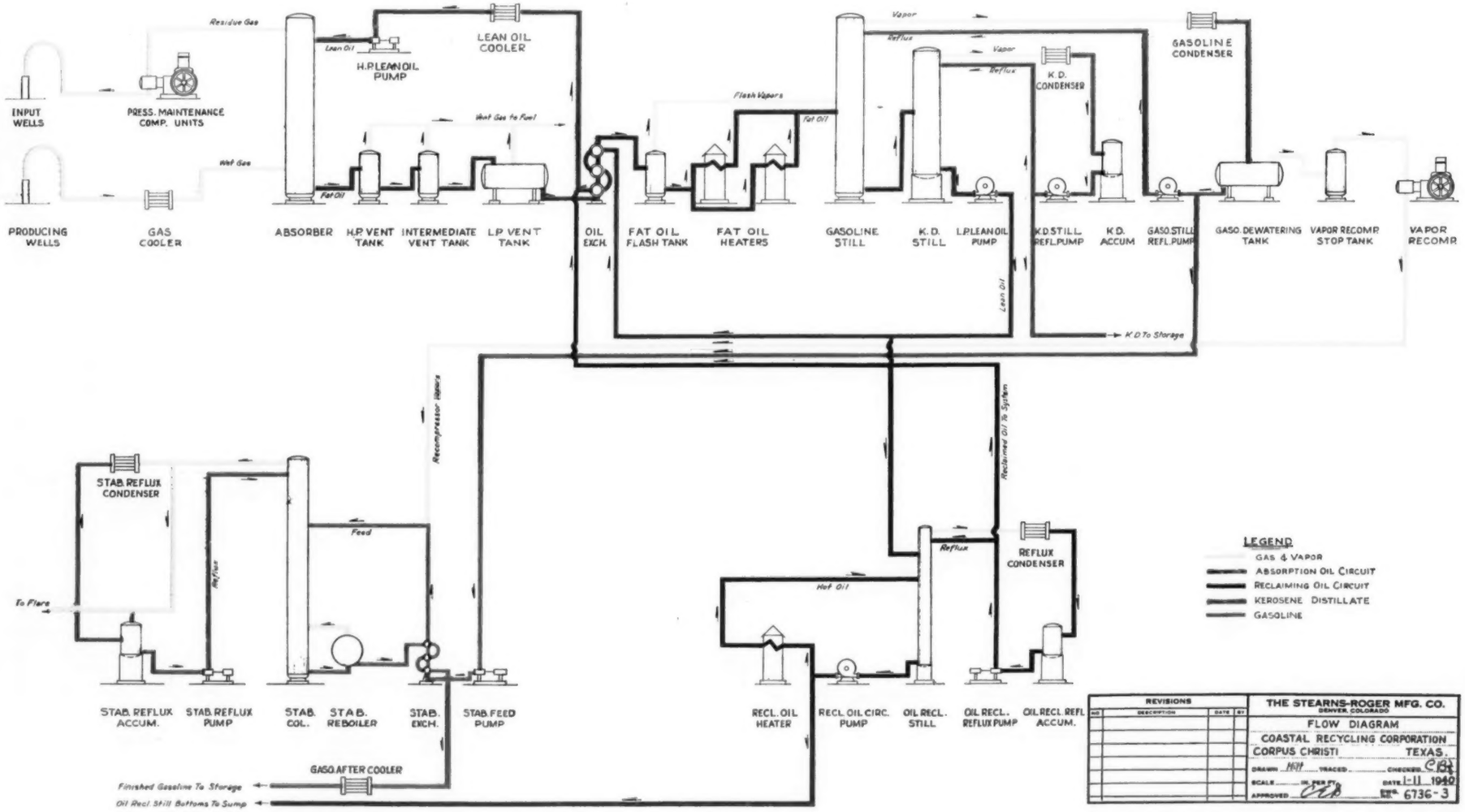
Fabricating the processing equipment in our own Shops;

Construction of the complete Plant, Field Line Systems and Well Connections by our own field organization;

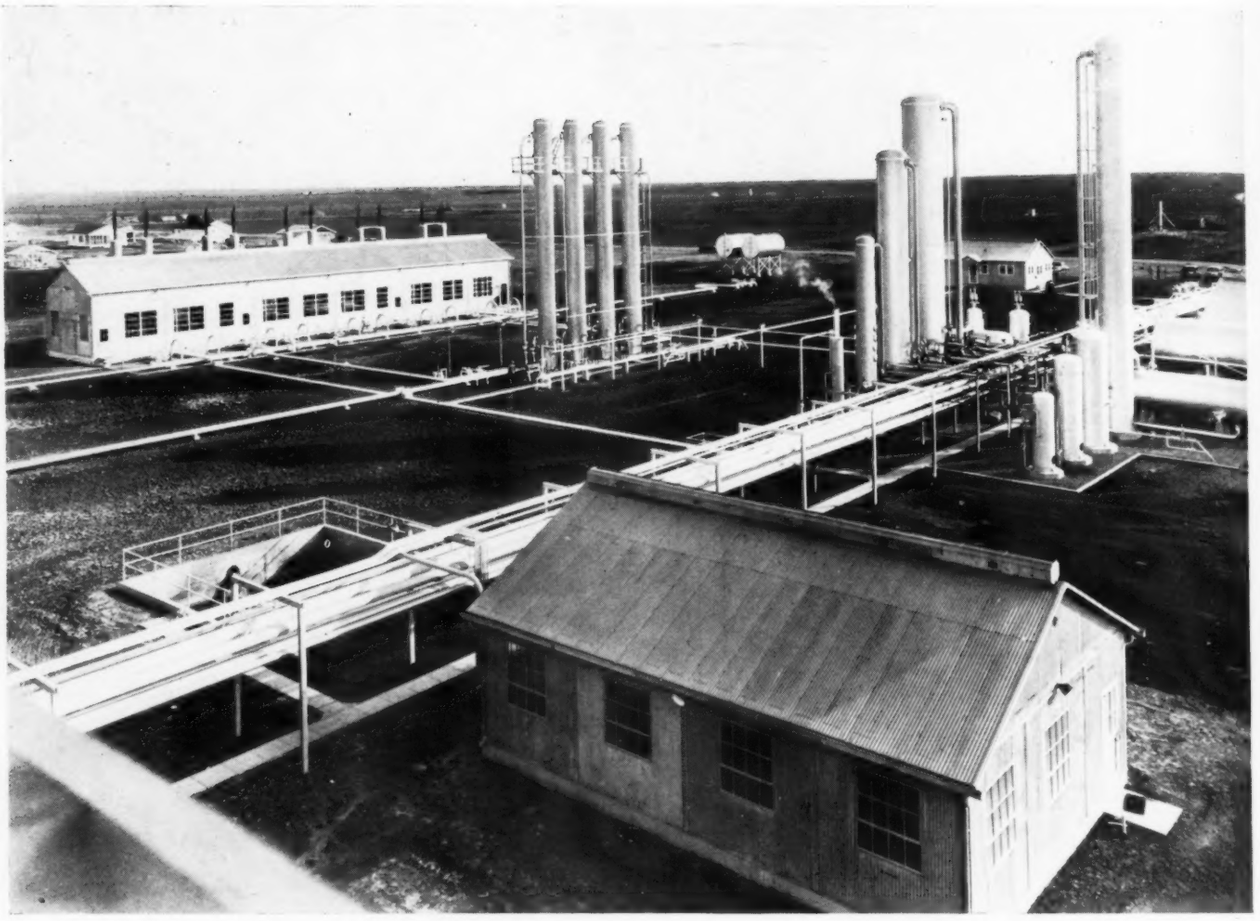
Testing and Starting the Plant; Delivering it to our customer as a complete operating unit.

The STEARNS-ROGER Mfg. Company
Denver, Colorado

PARKHILL-WADE
Los Angeles, California



Flow Sheet of Coastal Recycling Corporation's Plant



Generous spacing of facilities is keynote of neat plant arrangement pictured above

and an efficient scrubber, which is designed to reduce mist formation and is mounted in the upper section. This scrubber section not only prevents the carry-over of liquid from the absorption process, but the chamber in which it is placed also serves as a protection to the compressors. This chamber is equipped with an internal float that, in the event of a dangerous liquid level in the top part of the absorber, will operate to shut-off fuel to the engine compressors. These absorbers were fabricated of high-tensile-strength steel made under A.S.T.M. Specifications A-150. The vessels were completely X-rayed according to the A.P.I.-A.S.M.E. Code and were also stress-relieved.

Leaving the base of the absorbers, the fat oil is controlled by internal floats and from that point passes through three stages of controlled weathering. Pressure reductions in these three weathering stages are designed to produce a minimum overhead loss in the gas evolved. From the third stage of weathering the fat oil passes through the heat exchangers and into the fat-oil flash separator. In this flash tank the vapors separated by the preliminary heating in the exchanger are removed from the liquid and carried directly to the high-pressure gasoline still, thus avoiding passing them through the oil heaters.

The fat oil from the separator is proportioned to the two direct-fired oil heaters wherein the temperature is raised to meet the operating temperature required in the high-pressure still. The oil heaters are arranged back-to-back, and are connected to a common breeching and a single stack. Temperature of oil leaving the heaters is controlled by temperature controllers, which regulate the volume of fuel gas to each heater. From the heaters the fat oil enters the high-pressure still. Here the fat oil is fractionated, in combination with the gases previously driven off in the fat-oil flash separator, resulting in an overhead product of gasoline and a bottom product of a mixture of absorber oil and distillate. The end point of the gasoline is controlled by the quantity of refluxed gasoline over the top of the still, and the initial boiling point of the kerosine or distillate is also controlled in this still by the quantity of agitation steam used in the stripping section.

The oil bottoms from the high-pressure still, denuded of gasoline, are flashed into the atmospheric still wherein a kerosine or distillate cut is removed. The quantity and quality of overhead from this tower may be varied by adjusting the amount of reflux or the amount of agitation steam used, or both, depending on what is desired in the overhead product and the quantity of light material that can be tolerated in the absorption oil.

The bottoms from the atmospheric still go to the hot-oil pump, which discharges through the oil exchangers to the absorption-oil coolers situated in the base of the cooling-tower structure. From there the high-pressure oil pumps force the lean oil into the absorbers. The pump delivering the oil to the exchangers and coolers is an electric-motor-driven, refinery-type, self-venting centrifugal pump. The three high-pressure lean-oil pumps are forged-steel, outside-end-packed, motor-driven units taking suction at 20-lb. pressure and discharging at absorber pressure.

To keep the absorption oil in a

A completely-equipped laboratory is a part of the plant's equipment

proper condition, a side stream of hot oil is diverted from the discharge of the hot lean-oil pump to the oil-purification still. Through the lower part of this still, circulation is maintained by pumping through a small direct-fired oil heater, in which the temperature is increased by any desired amount. This permits fractionation in the oil-reclaiming still to obtain an overhead product, which is condensed and returned to the absorption-oil system just before the oil enters the lean-oil coolers in the cooling tower. Thus the lean oil pumped over the absorbers can be cleaned and adjusted for end point and molecular weight. The heavy ends removed from the absorption oil in the oil-reclaiming still, as well as any dirt and products of decomposition, go to a burning sump.

Gasoline from the high-pressure still is condensed in atmospheric cooling sections in the tower, returned to a 25,000-gal.-capacity horizontal accumulator, and then passed to the stabilizer column. This accumulator also serves as a dewatering tank and separator for the uncondensable vapors from the high-pressure still. Water is discharged from the tank automatically and the uncondensable vapors are collected for compression and injection into the stabilizer. Stabilized gasoline goes from the stabilizer reboiler through an exchanger and aftercooler to storage.

The plant storage facilities consist of two 20,000-bbl. floating-roof tanks for gasoline, two 2,000-bbl. cone-roof tanks for kerosine, two 500-bbl. tanks for absorption oil, one 2,000-bbl. tank for water, one 600-bbl. elevated tank for jacket water, and two 12,000-gal. horizontal lube-oil storage tanks.

The cooling tower is an induced-draft structure, arranged for cooling the water in the upper section. The lower part of the tower includes a collecting basin for the redistribution of the cooling water over the atmospheric cooling sections mounted in the base of the tower. Valves are provided in the redistribution system to regulate the amount of water diverted to each cooling section. The cooling tower is 25 ft. wide by 192 ft. long, and is equipped with seven 11½-ft. diameter fans, each driven by a 25-hp. motor. The maximum water circulation over the tower is 8000 gal. per min., although the quantity of water as well as the number of fans in operation can be varied to suit atmospheric conditions. The atmospheric cooling sections in the base of the tower serve collectively to condense and cool all products, and cool the lean absorption oil and the engine-jacket water.

An electric generating plant is installed to supply all the necessary electricity for power and lighting. In this plant are three 400-hp. gas engines, each driving a 250-kw., 440-volt, 60-cycle generator having a direct-connected exciter. The plant can be operated in two units, while the third is shut-down for maintenance or repairs.

The use of electric power for driving much of the equipment, plus direct-fired preheaters, made it possible to hold the steam requirements to a minimum. This was desirable because of the poor quality of water available. The steam plant consists of four 125-hp., 250-lb. working pressure, oil-field-type boilers. Any three of these boilers will carry the entire plant load, allowing one for standby.

Water for the plant is provided by a 10-in. gravel-packed well drilled to a water sand at a depth of 600 ft. Water is lifted by an electric-motor-driven, deep-well centrifugal pump. A gas-lift water well is provided as a standby source of supply.

The pressure-maintenance part of the plant consists of five 800-hp. angle-type, direct-connected gas engine compressor units, four of which are each equipped with four 4¼-in. double-acting forged-steel compressor cylinders to compress the stripped gas for return underground. The other unit has three similar cylinders and one double-acting cylinder for compressing gasoline-accumulator vapors to a pressure at which they will flow into the stabilizer. The high-pressure residue gas that is to be returned to the formation is compressed in one stage without aftercooling and is discharged direct to the input pipe-line system. Engine and compressor cylinders are cooled by a closed water system. This same system also serves to cool the gas-engine cylinders on the electric-generating units. The circulation through the jackets is maintained by a centrifugal motor-driven pump. An elevated water tank floats on the jacket-water system. Should the main jacket-water circulating pump stop for any reason, this reserve supply allows ample time for starting the standby pump.

The compressor units are arranged in a single row. To insure a solid foundation for the compressors, a reinforced-concrete mat was poured over the entire area occupied by the machines and extended the full width of the building. On this mat were placed the individual foundation blocks for the machines.

The compressor units are protected from oil failure and circulating-water failure by pressure- and temperature-control switches that cut-off ignition in case of failure. Oil-bath air filters protect the power cylinders from damage due to dust.

Pipe Lines

The system of piping for collecting the gas from the field and redistributing it again to the input wells deserves some comment. The gas gathering lines consist of a 10-in. main, approximately two miles long, collecting the gas from

Top deck of induced-draft cooling tower showing motor-driven fans

the producing wells in the south part of the field, and a combination 8-in. and 6-in. main, about five miles long, bringing the gas in from the north end of the field. Lead lines from the wells to the main lines vary in size from 3 in. to 6 in. The gathering system is designed for a normal operating pressure of 1500 lb. per sq. in. and a maximum working pressure of 2000 lb. per sq. in. The system was completely tested hydrostatically to 3500 lb. per sq. in.

Assuming a nominal pressure drop, the south end of the system has a delivery capacity to the plant of 100,000,000 cu. ft. per day, and the north end, 50,000,000 cu. ft. per day. At the present, a total of 20 producing wells are connected to the gathering system. Additional producing wells are now being drilled and it is expected that a total of 35 wells will eventually be connected.

At each producing well, the wet gas is metered with an orifice meter the flanges of which are installed in a vertical setting. Each setting is equipped with seal pots filled with ethylene glycol. This chemical provides sufficient dehydration to prevent hydrates forming in the meter and meter piping. Without the ethylene glycol, hydrates may form in the meter or connecting lines when the atmospheric temperature drops below about 60°F.

The gas-input system, like the gathering system, consists of a south and a north branch. The south lines comprise a 10-in. main with 6-in. laterals connected to four input wells. The north branch is a combination 8-in. and 6-in. main line connected to two input wells. The maximum distance of an input well from the plant is approximately five and one-half miles. The input system is designed for a working pressure of 2500 lb., and was given a hydrostatic test of 4500 lb. per sq. in. At each input well the gas is metered with a 6-in. orifice meter. Each input well is also equipped with a ball-type check valve to prevent the back-flow of gas if for any reason the pressure should drop in the discharge lines or in the plant.

To market the plant products it is desirable to transport them to Corpus Christi and make them available at the water front. To do this a duplex piston pump has been installed, driven by a 75-hp. electric motor. The pump unit is connected to the gasoline storage, kerosine storage, and water storage. It is thus possible to pump the various products from the plant to the shipping facilities through the one pipe line by introducing a "slug" of water between batches of the various products to prevent their mixing.

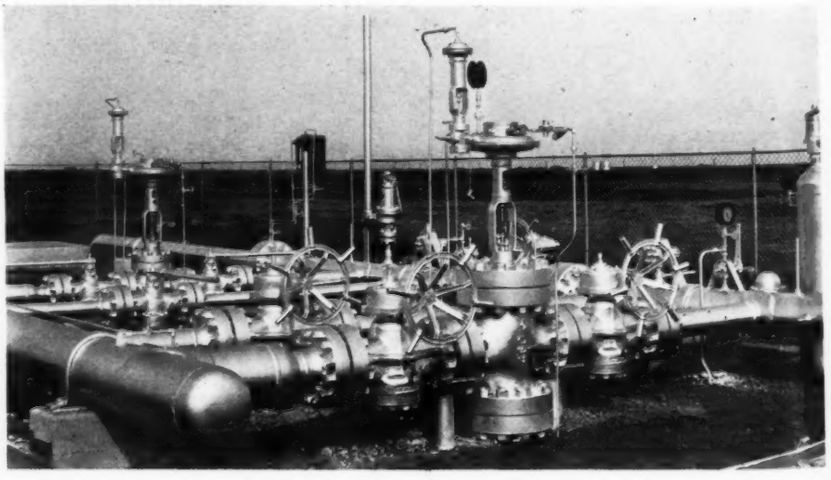
General

Steel buildings house process pumps, generators, boilers, office, and laboratory. The buildings themselves are of steel frame and truss construction sheathed with corrugated galvanized iron. Ventilating windows and unusually large roof ventilators are provided.

All high-pressure gas and oil piping is installed aboveground on concrete piers. A variety of anchors and straps is used, depending upon provision necessary for expansion and contraction. All other plant piping as far as practicable is installed overhead. Only water lines and pump suction lines are belowground. Grade "B" seamless pipe is used entirely for all high-pressure piping both in the plant and in the field lines. A total weight of approximately 2000 tons of pipe was used in the 30 miles of gas gathering and input systems.

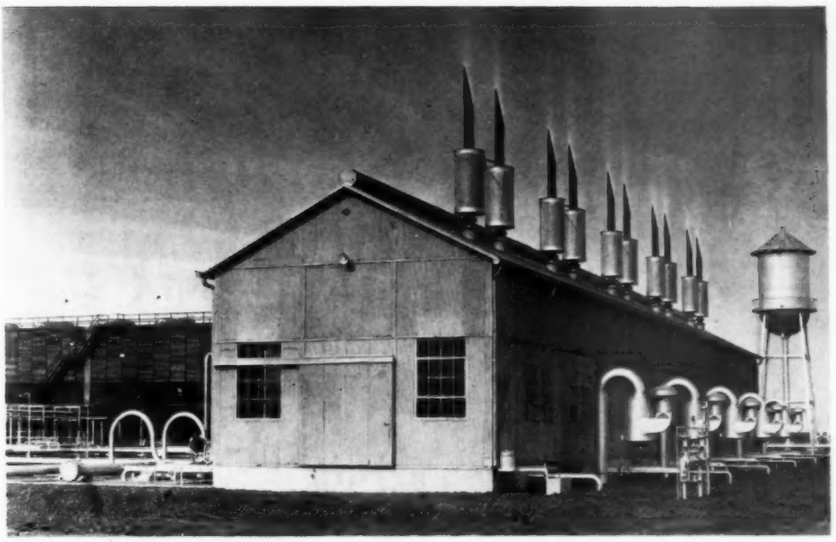
At all operating points of the plant, automatic temperature, pressure, and flow-recorder controllers have been provided. Proportioning meters are of the indicating dial type.

As a safety measure, a system has been designed to shut-down the plant completely if an emergency arises, by the turning of a single lever. Several stations have been provided at points where they can be easily reached with a maximum of speed and safety. All gas coming into the plant and high-pressure gas leaving the plant is cut-off at the plant boundary, all high-pressure gas lines and vessels within the plant are dumped to the flare line, compressor units are shut-down, fuel to the oil heaters is shut-off, and steam is released into furnaces. This is accomplished through remote-controlled lubricated plug cocks operated by power cylinders and diaphragm valves.



Regulators and gear-operated plug valves in this compact manifold control gas coming into plant

Air filters and compressor exhaust silencers



A PETROLEUM ENGINEER EXCLUSIVE FEATURE

By
HENRY N. WADE
President, Parkhill-Wade

Engineering Considerations Underlying Design of Plant

Absorption process adopted to obtain efficient extraction at high operating pressures—direct-fired heater essential in providing required heat to fat oil—induced-draft cooling tower employed to cope with high atmospheric temperatures, high humidity, and low wind velocities

THE new Coastal Recycling Corporation's distillate recovery plant embodies several features of design that differ from conventional practice in absorption plants operating under more ordinary conditions. The main departures from usual designs fall under the following general headings: (1) Extreme high pressure absorption; (2) Direct-fired fat oil heater; (3) General use of electric power, and (4) Induced-draft type cooling tower.

The reasons for adopting these features will be briefly discussed.

High Pressure Absorption

Two general types of plants have been developed for the recovery of liquid hydrocarbons from the so-called "distillate" type natural gases: expansion-and-refrigeration plants, and absorption plants.

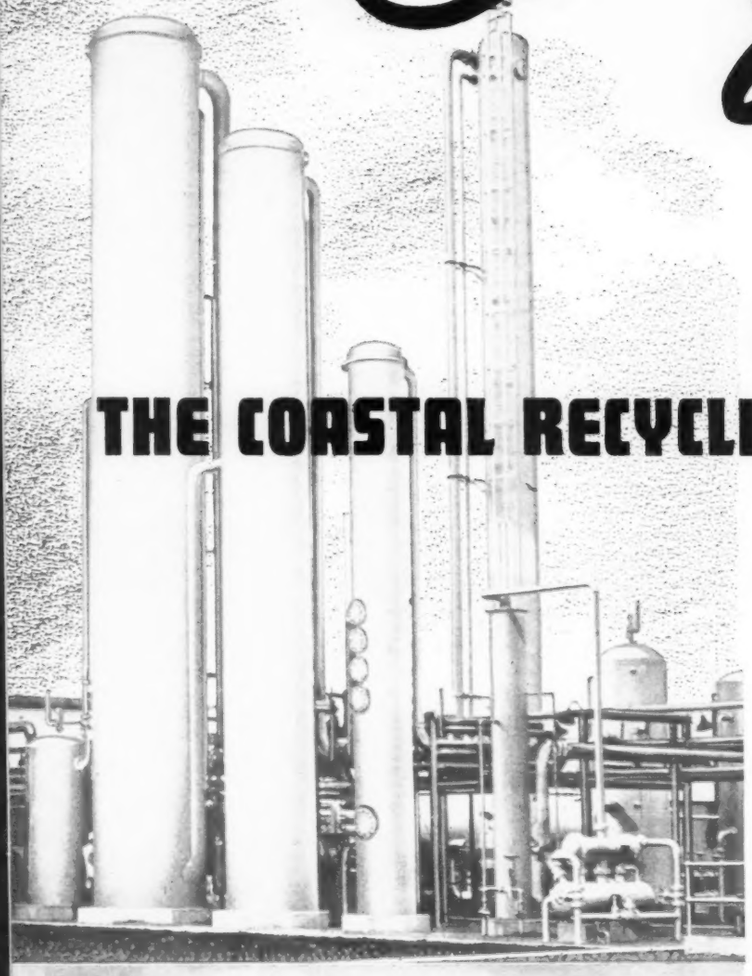
In the expansion-and-refrigeration plants the gas is conducted from the wellhead to the plant at as high a pressure as possible. There it is cooled, with or without artificial refrigeration, and expanded to some lower pressure, at which the liquid condensed is separated from the gas. The condensed liquid is fractionated into marketable products and the residual dry gas is compressed and returned to the producing formation. On account of the limitations imposed by retrograde condensation, it has been found that the pressure in the gas-from-liquid separator cannot greatly exceed 1200 lb. per sq. in. To obtain reasonable extraction efficiencies even at this relatively low pressure, it is necessary to carry a separator temperature of about 20°F. or less. In the case of gases containing relatively heavy liquid vapors this process may result in efficient extraction. Gases containing lighter vapors that yield liquids of low end point (say 350° to 400° F.) require a still further reduction of separator pressure or temperature, or both, in order to attain reasonable efficiency.

The absorption process, in the opinion of the writer, has several important advantages over expansion-and-refrigeration. The greatest advantage is the fact that absorption affords efficient extraction at pressures much higher than those permissible in the refrigeration process. It is established that operation of absorbers at 1500 lb. per sq. in. pressure is entirely practicable; calculations and tests indicated that absorber pressures at least as high as 2000 lb. are entirely feasible. Even the difference between 1200-lb. and 1500-lb. operation has a serious effect on the amount of compressor power required to return the stripped gas to the formation. In the case of several plants in the Agua Dulce area the required compressor discharge pressure is about 3000 lb.

HENRY N. WADE

received the degree of mechanical engineer from Cornell University in 1914—Undergraduate work was obtained at the University of Southern California in 1909-10—Served as development engineer for Cutler-Hammer Manufacturing Company, 1914-21—Was with Keystone Iron Works, Los Angeles, 1921-23—Served as manager, natural gasoline plant, U. S. Refining Company, Los Angeles, 1923-26—Acted as sales representative and sales engineer, respectively, for Lincoln Electric Company and J. A. Campbell Company, 1926-32—Has held the position of president of Parkhill-Wade since March 15, 1932.

Continental Equipment



MET EVERY TEST AND REQUIREMENT

on

THE COASTAL RECYCLING CORPORATION PLANT

Continental equipment was selected by The Stearns-Roger Manufacturing Company for the world's largest high-pressure recycling plant built for the Coastal Recycling Corporation at Agua Dulce, Texas.

This is added recognition for the products and service offered by Continental to those operators and engineering firms engaged in the recycling industry.

THE CONTINENTAL SUPPLY CO.
General Offices: DALLAS, TEXAS

Foreign Sales Subsidiary
CONTINENTAL EMSCO COMPANY, Inc.
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CONTINENTAL

SERVING THE OIL AND GAS INDUSTRIES

Compression from 1200 lb. to 3000 lb. requires about 56 hp. per daily million cu. ft., whereas compression from 1500 lb. to 3000 lb. takes only 43 hp., a difference of 1300 hp. in a plant of 100 million cu. ft. capacity. If well conditions permitted operation of the plant at 2000 lb., the hp. per daily million cu. ft. would be reduced to about 29, or only 52 percent of that required by a 1200-lb. plant.

Perhaps an equally important feature of the absorption process is the fact that it affords practically equal efficiency in the extraction of marketable materials from distillate gases of all types. Extraction efficiencies of 96 percent to 98 percent of the pentanes-plus content are easily and economically attained. Such efficiencies require separator temperatures far below 0°F. in handling the "lighter" types of distillate gases by the refrigeration process. The plant complications introduced by such low temperatures may easily cause the recovery unit itself to cost more than the absorption unit.

In the case of the Coastal Recycling Corporation's plant it was necessary to provide for efficient handling of the "light" distillate gases from the upper sands in part of the producing area, as well as the heavier gases from the lower sands. The absorption system offered the most efficiency at the lowest overall plant cost. The maximum absorber pressure was fixed at 1500 lb. principally because a considerable number of the wells served are unable to deliver a reasonable volume of gas to the plant at a higher pressure.

Direct-Fired Fat Oil Preheater

The heat input to the fat-oil stream required of the preheater amounts to about 25 million B.t.u. per hr. If it were feasible to attain the required fat oil temperature by a conventional steam preheater, this heat load would require about 820 boiler hp. The installed cost of this boiler capacity, plus that of the steam preheater itself, proved to be materially higher than the cost of the direct-fired unit with its controls and accessories. Further, in order to distill kerosine economically from the fat-oil stream, as required in this plant, it is necessary to heat the oil to 550°F. or slightly above. Such temperatures are not attainable with steam heat without using excessively high steam pressures.

The heater selected was designed particularly for this type of work; that is, relatively low commodity temperatures, combined with utmost precautions to prevent local overheating of the oil.

At full rated capacity, the rich oil is split into two equal streams, one to each heater. The oil enters the convection banks at about 300°F., and is heated in these tubes to about 375-410°F. The flow is then through the radiant roof tubes, wherein the temperature is raised to approximately 450-470°F. The final flow through the floor tubes develops an outlet temperature of 500-550°F. The range given varies as the outlet temperature varies but the percent of temperature pick-up at each section remains fairly constant.

Short-flame gas burners are used in a furnace containing ample combustion space, so that flame impingement on the heater tubes is impossible. This general design, combined with high oil velocities through the tubes, gives maximum insurance against local hot-spots. Previous tests of similar heaters have shown that maximum localized temperatures in the oil do not exceed the average oil temperature by more than 25°F.

Experience with the heater in the Coastal Recycling Corporation's plant so far indicates that there is no slightest trace of cracking of the absorption oil. The oil reclaiming or cleaning unit has been operated only occasionally, to remove small amounts of heavy brown waxy material, apparently derived from the raw distillate entering the plant. Even the heavy dark residue from the reclaimer unit shows no signs of cracking.

Use of Electric Power

The total full-load pumping duties in the plant amount to about 500 hydraulic hp. Taking into account the efficiencies of suitable types of pumps for the various duties, full steam drive would require about 1700 boiler hp. As all water supplies available are badly polluted by soluble and scale-forming salts, it would be necessary to condense all exhaust steam for boiler-feed; this would have very greatly increased the size of the cooling-tower and auxiliary equipment.

Individual gas-engine drives were considered as an alternate possibility, but were abandoned because of first cost, maintenance expense, and the difficulty of making fire-safe installations where pumps handle inflammable materials.

The power scheme that was adopted, using electric motor drives supplied with power from a central gas-engine driven generating plant, showed a decisively lower first cost, and gives promise of very satisfactory maintenance costs. In addition, the utmost in neatness of installation and convenience of operation has been obtained.

The electric generator units are sized so that any two of the three units can carry the essential plant operating loads. When all three units are running there is ample capacity for all plant duties plus the operation of the shipping pump, water-well pumps, and all camp facilities, with unusually low mean effective pressures in the generator unit engines.

Comparison of the three possible schemes of powering the plant showed advantages in favor of the full electric drive: (1) Substantially lower installed cost; (2) Saving of about 150,000 gal. per day of raw water for cooling tower; (3) Probable lower maintenance costs, and (4) Greater convenience and cleanliness.

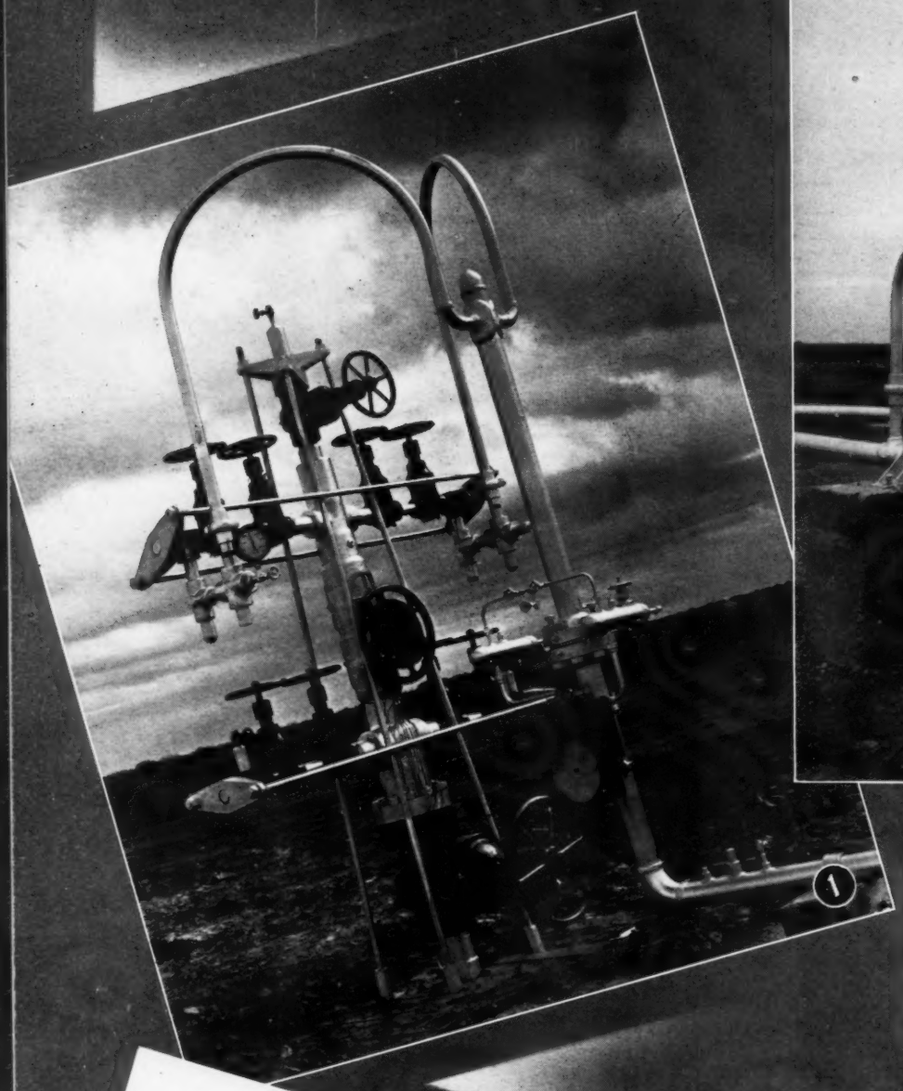
It should be remarked that in plants having smaller total power requirements the first-cost advantage may disappear, or may even be reversed.

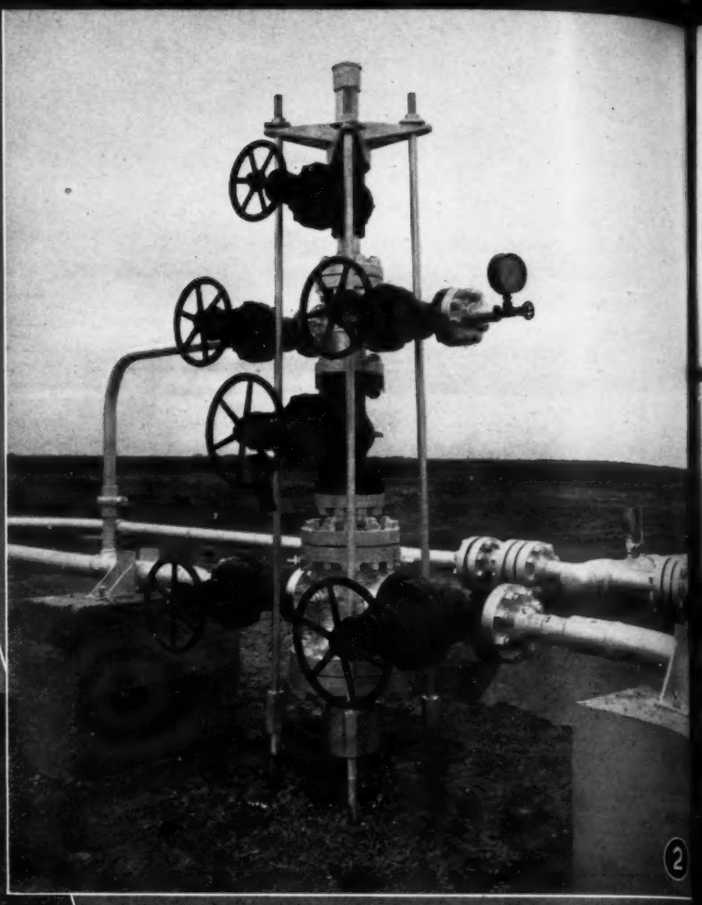
Induced-Draft Cooling Tower

The Coastal Recycling Corporation's plant is situated where moderately high atmospheric temperatures and high relative humidities prevail. Average wind velocity is fairly high, but during normal summer weather there is a period of 4 to 6 hr. duration every night when the wind dies completely. During this period the cooling performance of ordinary deck-type cooling towers, which depend on external wind velocity for efficiency, becomes very poor.

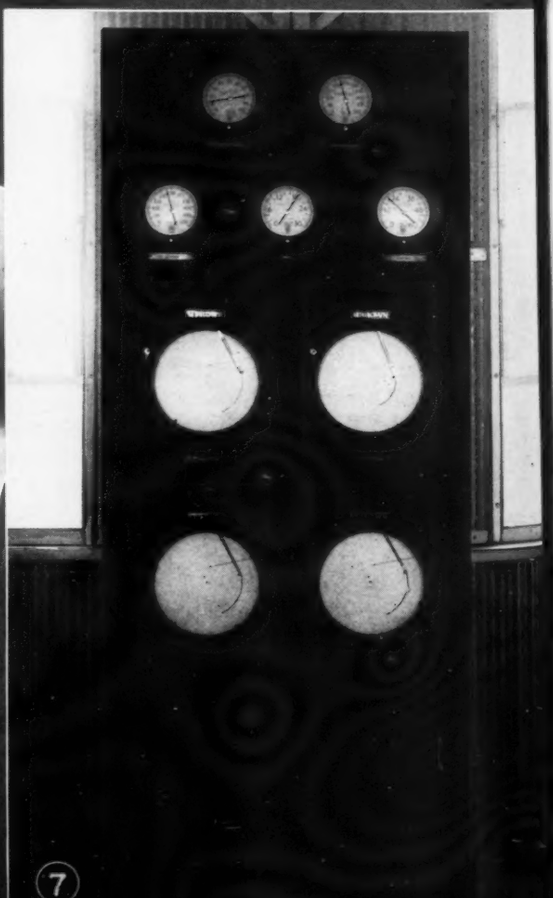
These conditions forced the consideration of the merits of the two types of cooling towers that do not depend on external wind movement; viz., water-spray induced draft, and power-driven fan induced draft. To overcome as far as practicable the disadvantage of high average atmospheric wet-bulb temperatures, it was decided to require a 5°F. approach of spray water to wet-bulb temperature.

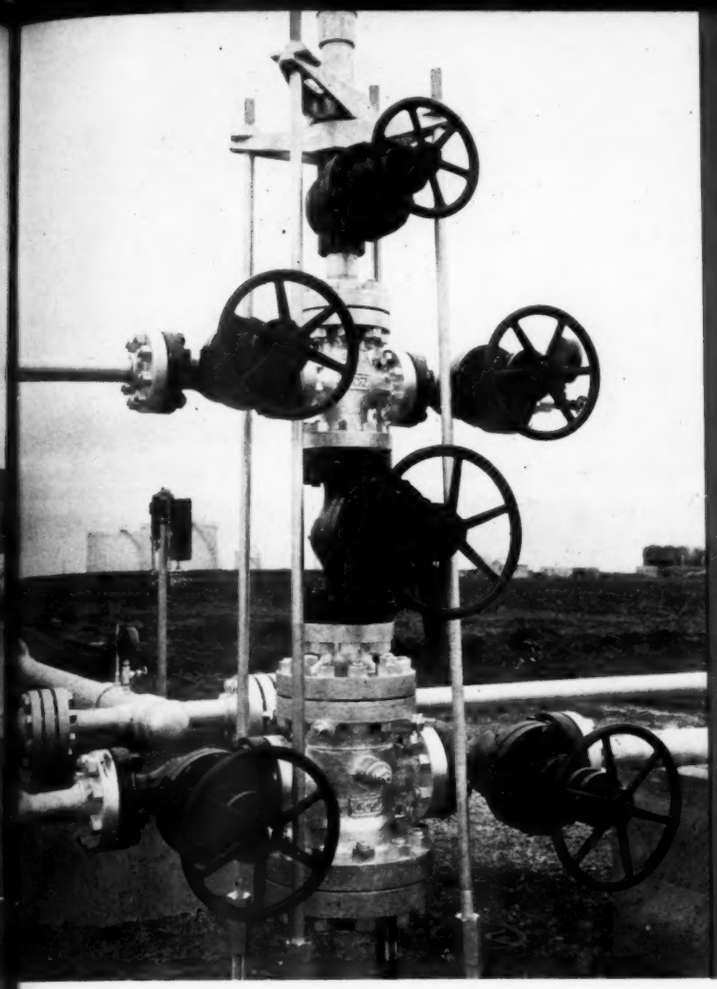
A cost comparison of the two complete cooling installations, including the cooling sections, water pumps, etc., showed a first-cost advantage in favor of the power-driven fan-type tower, and considerable power consumption advantage in favor of the water-spray induced-draft type. As electric power had already been chosen for the reasons given, the incremental first cost for the additional generator capacity required for the fans was moderate, and so the overall first cost favored the fan-type tower.





Equipment Through Which Gas Flows From Producing Well, Through Plant, to Key Well . . .





One of the 36 O·C·T TREES In the Agua Dulce Field!

SCENE OF COASTAL RECYCLING CORPORATION'S REPRESSURING PROJECT

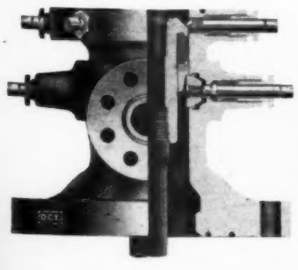
O-C-T TYPE T-26 TUBING HEAD PERMITS LANDING TUBING UNDER PRESSURE THROUGH SCREWED TYPE BLOWOUT PREVENTERS

In the Agua Dulce Field of South Texas, as well as a number of other high pressure fields throughout the country, you'll see row after row of O-C-T Christmas Trees assembled on the popular O-C-T Type T-26 Tubing Head. Numerous major and independent companies have standardized on this unique head.

The O-C-T Type T-26 Tubing Head, having retractable hanger seats, permits running and landing tubing under pressure *through screwed type blowout preventers.* As shown in the accompanying cross-section drawing, the O.D. of the tubing hanger is slightly smaller than the I.D. of the casing above which it is used. The utility and flexibility of the T-26 Tubing Head are clearly illustrated in the photograph below right, showing how an operator in the League City, Texas, field utilized a casing nipple between the 10,000-pound test Tubing Head and 6000-pound test control equipment, thus eliminating the need for expensive flanged adapters for this connection.

Don't throw away your screwed type blowout preventers! They can be used with perfect safety above the O-C-T Type T-26 Tubing Head for completing your well under pressure.

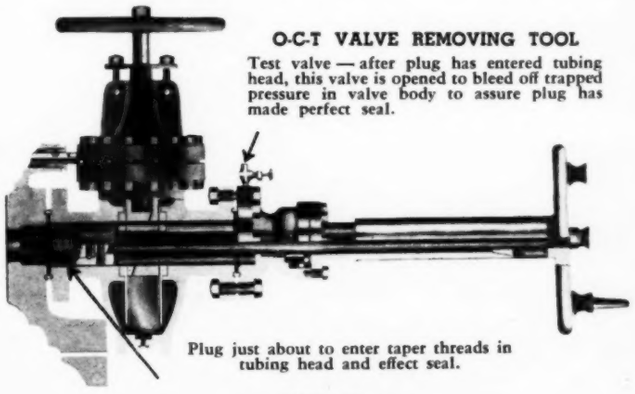
Above: Note casing nipple installed between master gate and O-C-T Type T-26 Tubing Head. Tubing hanger will pass through this threaded connection to seat in Tubing Head.



Cross-section view of O-C-T Type T-26 Tubing Head showing hanger seated on retractable seat. The flanged outlets in this head are threaded to receive a valve removing plug.

O-C-T VALVE REMOVING TOOL

Test valve — after plug has entered tubing head, this valve is opened to bleed off trapped pressure in valve body to assure plug has made perfect seal.



Plug just about to enter taper threads in tubing head and effect seal.

OIL CENTER TOOL CO.
QUALITY O-C-T PRODUCTS
HOUSTON, TEXAS, U·S·A

O-C-T Field Representatives: B. V. Fisher, H. D. Start, A. J. Penick, K. T. Penick, Paul Vachon, all of Houston, Texas; C. J. Hillman, Edinburg, Texas; H. S. Perry, Corpus Christi, Texas; Walter Burke, Odessa, Texas; C. K. Mount, Lafayette, Louisiana; I. C. Wells, Houma, Louisiana; J. E. Edwards, Lake Charles, Louisiana; H. C. Stewart, Shreveport, Louisiana.

O-C-T MANUFACTURES A COMPLETE LINE OF CONTROL EQUIPMENT FOR DRILLING AND PRODUCING WELLS

All Plant Equipment and Auxiliaries Meet Rigid Specifications and Include Latest Automatic Control Devices

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

High pressures and large capacity necessitated close study of equipment specifications to assure adequate safety and maximum performance

By E. E. DeBACK

General Superintendent, Coastal Recycling Corporation

THE combination pressure-maintenance, absorption-type gasoline plant recently completed in the Agua Dulce field, Texas, by the Coastal Recycling Corporation, is designed for operation at a pressure of 1500 lb. on the absorbers, 2000 lb. on the gathering lines, and 2500 lb. on the input system. Its capacity is 128,000,000 cu. ft. of gas per day. The significant feature of the project lies in the fact that it is the largest plant of its type in existence, from the standpoint of gas throughput, operating at such high pressures. Because of this, a detailed description of the construction and operation of certain equipment employed in the plant is of more than usual interest. With this thought in mind the present article is written to supplement those of Ray C. Fish of the Stearns-Roger Manufacturing Company and of H. N. Wade of Parkhill-Wade, appearing elsewhere in this section.

Main Compressors

There are five 800-b.hp., 2-cycle, right-angle, gas-engine-driven compressors. One unit is equipped with a single double-acting recompressor cylinder and three 4⅛-in., forged-steel, double-acting gas-recycling compressor cylinders. Each of the other four units is equipped with four 4⅛-in., forged-steel, double-acting compressor cylinders. These cylinders are designed to operate over a wide range of suction and discharge conditions, by means of changeable clearance plugs.

The engine end of the compressor units consists of a single row of power cylinders in a vertical position operating on the 2-cycle principle. The compressor cylinders and the double-acting scavenging cylinders are horizontal.

Engine Auxiliaries

Governor, magneto, and lubricator are driven from the layshaft. The oil pump is operated directly from the end of the crankshaft. The governor is a built-in, completely-enclosed, centrifugal type and can be adjusted by means of a handwheel.

E. E. DeBACK

received degree of A.B. in engineering from Stanford University, 1921, and M.S. in engineering from Massachusetts Institute of Technology, 1922 —Has served with Pan American Petroleum Company as assistant engineer, Wilmington Refinery—With Foster Wheeler Corporation, New York City, in Natural Gasoline Division—With Hercules Gasoline Company, Inc., Shreveport, Louisiana; designed, supervised construction, and operated that company's plant in East Texas field—He is general superintendent of the Coastal Recycling Corporation and the Corpus Christi Corporation, affiliated organizations.

The magnetos used are of the low-tension type. Because the high-tension system is confined to the short distance between each spark plug and its adjacent coil, this type of magneto is desirable in reducing the fire hazard of high tension sparks jumping to ground through leaky insulation. Using the low-tension magneto, a coil failure can affect only one spark plug and a new coil may be installed without stopping the engine.

Lubrication

All bearings are lubricated under pressure. The lubrication oil is picked-up in the crankcase by a gear-type pump and forced through a double filter to remove all dust, dirt, and other foreign matter of more than one-thousandth of an inch in diameter, after which it passes through the oil cooler. The oil then enters a header in the crankcase, from which it is distributed to the main bearings. From the main bearings it flows through holes drilled in the crankshaft to the crankpin bearing.

A mechanical force-feed lubricator having positive action pumps lubricating oil to each power cylinder at three points and thus assures lubrication completely around the bore. This same lubricator also pumps oil to the compressor and scavenging cylinders, as well as to the metallic packing on the compressor piston rod.

Compressor Cylinders

The gas-recycling compressor cylinders are made of forged-steel and are designed to operate at a maximum pressure of 4000 lb. per sq. in. These cylinders have a removable cast-iron liner and the cylinder barrel is encircled by a cast-iron case that serves as a water jacket.

The recompressor cylinder is fabricated of high-grade semi-steel, is completely water-jacketed, and has large, smooth gas passages to and from the valves.

Oil-Cooled Pistons

Oil-cooled pistons are provided for all engines. Oil is conducted upward through the connecting rod and piston to the crown of the piston, thus cooling the firing face and top rings. It is circulated in a closed chamber and then enters the downspout to the crankcase where it is combined with the lubricating oil and pumped through the filter and cooler and returned to the crankcase. The same oil is used for cooling and lubrication.

OF COURSE . . . *the Boilers in the* Coastal Recycling Unit *are Fired with* John Zink Burners!

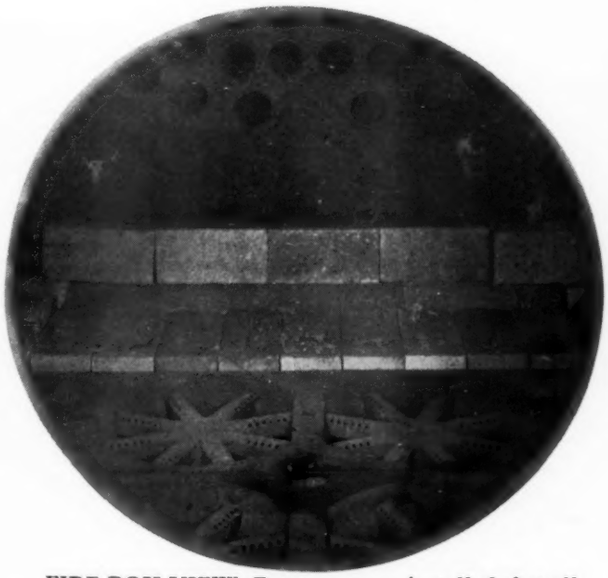
John Zink Bi-Mix Burners Can "Take it" —they are not damaged by slugs of water, oil, or gasoline that blow through them from the fuel line. Workmen may walk over them while inspecting the inside of the boilers.

They burn residue gas, or straight rectifying column vapors with a short flame without excess air and give CO_2 readings approaching the theoretical maximum.

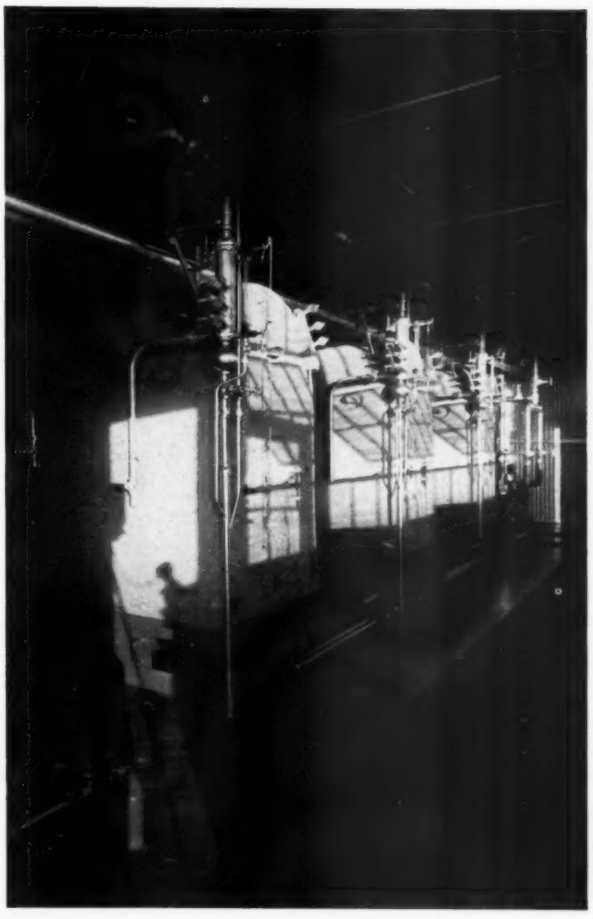
Easiest to Buy

Easiest to Install

Easiest to Maintain



FIRE-BOX VIEW. *Burners are so installed that all air entering the fire box passes through the radiating armed spiders.*



Showing piping arrangement to John Zink Vertical Bi-Mix Burners in the Coastal unit's boilers.

WRITE FOR DESCRIPTIVE BULLETINS

JOHN ZINK BURNERS

4401 S. Peoria Ave., TULSA, OKLA. **342 Madison Ave., NEW YORK, N. Y.**

Ample space is provided around the engines in the compressor building that accommodates a total capacity of 4000 hp. in an area of 3360 sq. ft.

Air Cleaners

Each compressor unit is equipped with a heavy-duty, self-washing, oil-bath air cleaner to protect it from internal damage by dust. The cleaners each have a maximum capacity of 5000 cu. ft. of air per minute. A light-grade lubricating oil is placed in the bottom of the cleaners, S.A.E. 20 grade being used in the summer months and S.A.E. 10 in winter. To fill each of the cleaners to the proper level requires 25 gal. of oil weighing approximately 185 lb. Each cleaner will catch and retain about 200 lb. of dirt without any appreciable increase in pressure drop across the cleaners, there being sufficient liquid oil left under the above conditions to provide efficient cleaning action.

Power Generators

The 936-kva. generating plant consists of three identical gas-engine-driven a-c. generators. Each generator is rated 312 kva., 80 percent power factor, 250 kw., 480 volts, 3-phase, 60-cycle, 600 r.p.m., open 40°C. rise, and is of standard horizontal-engine-type construction having a forged-flange shaft for bolting to the engine flange shaft and a bracket-type sleeve bearing on the outboard end. Included with each generator is a 6.4-kw., 125-volt, d-c., direct-connected exciter. The generators are designed for 10 percent continuous overload with a temperature rise not to exceed 50°C. over an ambient temperature of 40°C.

The three 400-b.hp., 600-r.p.m., vertical, 4-cycle engines are gas-Diesel convertible, but in this instance are operating as gas engines.

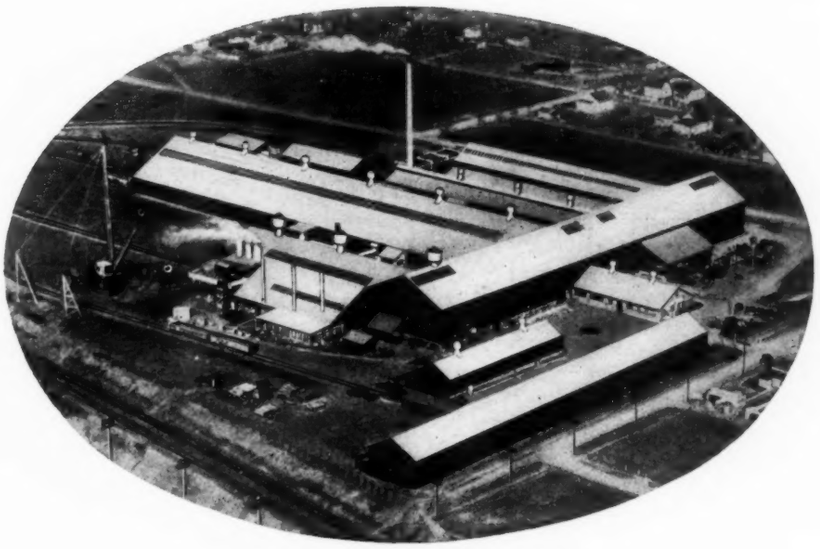
These engines are built for continuous heavy-duty service; however, their medium speed and efficient combustion performance are responsible for the low weight and small space requirements, which broaden their application to include semi-portable as well as stationary power requirements. Added flexibility is imparted to the engine by the ability to adjust it to burn fuels of varying ignition quality; conversion to gas is easily obtained by changing only the cylinder heads.

The 4-cycle principle upon which the engines operate is readily adaptable to variable-speed service, facilitates quick acceleration, and is susceptible to extremely close speed regulation for constant-speed parallel generator drives.

In the fuel system, gas is supplied through a regulator to the mixing valve at 5- to 6-oz. pressure. The mixing valve is placed on the end of the inlet manifold near the governor control. The flow area of the manifold is unusually large to give low resistance and high engine volumetric efficiency. The resulting low velocity in the manifold insures (1) an even distribution of the mixture to all cylinders and (2) equalized exhaust temperature, without the necessity for throttles or adjustment at each cylinder inlet.

Lubrication of all moving parts is entirely automatic. Oil supply is carried in the base of the engine, eliminating an external oil tank. The lubricating oil pump in the gearcase picks up oil from the base of the engine through a strainer and forces it through the oil filters built into the gearcase. The oil then passes through a cooler and enters the engine at the forward end of the base and flows through a cast-in steel pipe that is connected to each main bearing by a drilled hole. The main bearing is so grooved and drilled that it feeds oil continuously to the crankpin

55 YEARS AS MANUFACTURERS



Stearns-Roger Shops at Denver, Colo.

Pressure Vessels and Processing Equipment
built in our Denver Shops
for
COASTAL RECYCLING CORPORATION'S
CORPUS CHRISTI PLANT

Our Denver Shops have complete facilities for fabrication under A.S.M.E. and A.P.I.-A.S.M.E. codes, including . . .

1. Latest Automatic Welding Equipment;
2. Stress-relieving Equipment;
3. X-Ray Equipment.

THE STEARNS-ROGER MFG. CO.

ENGINEERS
CONTRACTORS

— DENVER, COLO. —

DESIGNERS
MANUFACTURERS

bearing through a drilled hole in the crankshaft. Oil then travels up the rifle-drilled connecting rod to lubricate the piston ring and cool the piston crown and ring belt. After cooling the piston the oil is fed into an oil catcher that drains it back to the engine base from whence the oil pump forces it through filters and cooler.

Lubrication of the gears and gear spindle bearings is accomplished by connecting to the cast-in oil header situated in the base of the engine. Lubrication oil is carried under pressure to each spindle bearing and an oil stream is sprayed on the gears.

To cool the engines, water first passes through the oil cooler and then enters at the forward end of the engine into a header cast into the upper frame.

For the convenience of the operator, controls are grouped on the forward end of the engine adjacent to the instrument board.

The engine is equipped with automatic shut-down safety devices for low oil pressure, high cooling-water temperature, and overspeed. In addition, there is a spring-loaded decompression lever than can be tripped manually. This device opens all exhaust valves and will stop the engine immediately regardless of its speed.

Each engine is equipped with a 20-in. diameter air cleaner having a maximum capacity of 1500 cu. ft. of air per minute.

A special feature of the air-cleaner installation is the use of a backfire relief valve in the air-induction system between the cleaner and the mixing box on the engine. The relief valves are installed at the top of the vertical riser pipe that extends from the top of the cleaner.

Applying cold coating to field line

Motors and Controls

The main motors used in the plant are of the constant-speed, squirrel-cage induction type and are operated by 440-volt, 3-phase, 60-cycle current. The motors are of two construction types, (1) rigid cast-iron, open-frame motors rated 40°C. for non-hazardous applications, and (2) totally-enclosed, fan-cooled, explosion-proof motors rated 55°C. for hazardous locations.

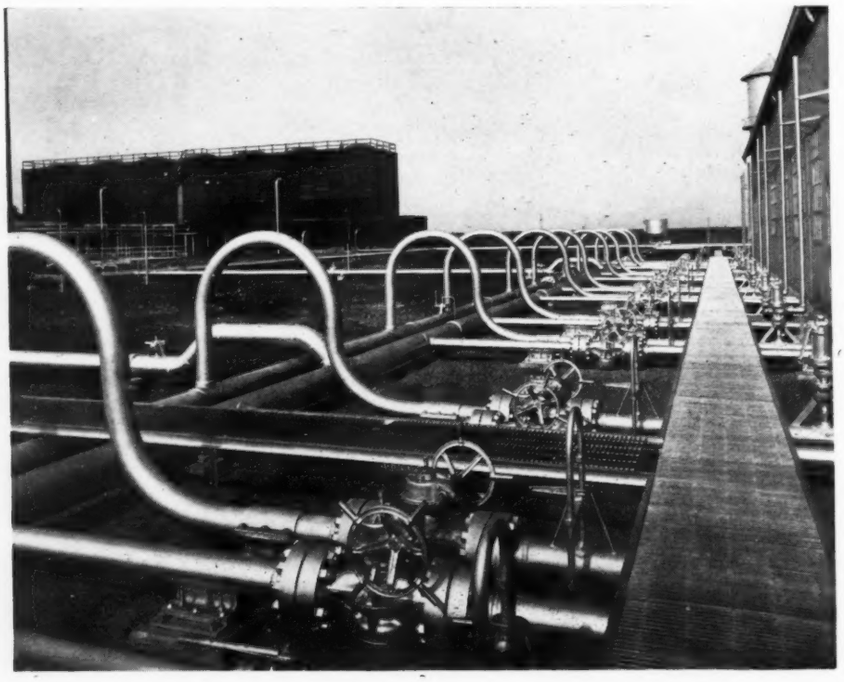
Explosion-proof motors consist of three 100-hp., 1750-r.p.m. units for driving the high-pressure lean-oil pumps; and two 15-hp., 3550-r.p.m. units for driving the reclaiming oil circulating pumps. The open motors consist of two 75 hp., 1750-r.p.m. units to drive the jacket-water pumps and two 60-hp., 1160-r.p.m. motors to drive the cooling tower pumps. In addition, there are seven 25-hp. motors driving the cooling tower fans, two 7½-hp. motors driving the primary still reflux pumps, and two 5-hp. motors driving the secondary still reflux pumps.

The type of motor control varies with the application. In general, all motors of 60-hp. and above employ reduced-voltage starting, whereas the smaller motors are started on full voltage by means of line-starters. The motors driving the jacket-water pumps and the cooling-tower pumps are controlled by manually-operated, reduced-voltage, auto-transformer starters mounted near their respective motors. Reduced-voltage, magnetic auto-transformer starters mounted in non-hazardous locations, and explosion-proof pushbutton stations mounted on their respective motors, control the motors driving the high-pressure lean-oil pumps and the hot-oil pumps. All line-starters are explosion-proof and have cast-iron enclosures and built-in push-buttons.

Cooling Tower

The cooling tower, which has a capacity of 8000 gal. per min., is 24 ft. 10 in. wide and 39 ft. 6 in. high. The height takes into consideration a coil shed 10 ft. in height over which the tower proper is constructed. This coil shed, or substructure, is arranged on thirty-two 6-ft. bays to accommodate the cooling coils, and the entire substructure is equipped with redwood louvers. Each 6-ft. section of the redwood collecting basin has a cast-iron redistribution spray system and flapper valve above the coil so that sections can be taken out of service when necessary. The tower proper is 168 ft. 10 in. long with 12 ft. additional at each end for the extended length of the coil-shed substructure, giving a total overall length of 192 ft. 10 in.

At the top of the tower are seven 138-in. fans having conical fan inlets of redwood. Each fan is driven by a 25-hp. splash-proof motor of 1750 r.p.m.,



Gear-operated plug valves, walkways, and expansion bends are features of this aboveground manifold of compressor lines

TECPRO PIPE COATING

PROTECTS ALL LINES OF THE COASTAL RECYCLING CORPORATION

AGAINST RUST AND CORROSION

Some of the first lines in the Agua Dulce field were treated with TecPro, and inspection by engineers for subsequent builders of recycling plants revealed that this coating, because of its superior adhesion, its relatively high melting point, and its other desirable physical qualities, provides the ideal type of protection for lines carrying hot gases and those subject to a wide variation in temperature.

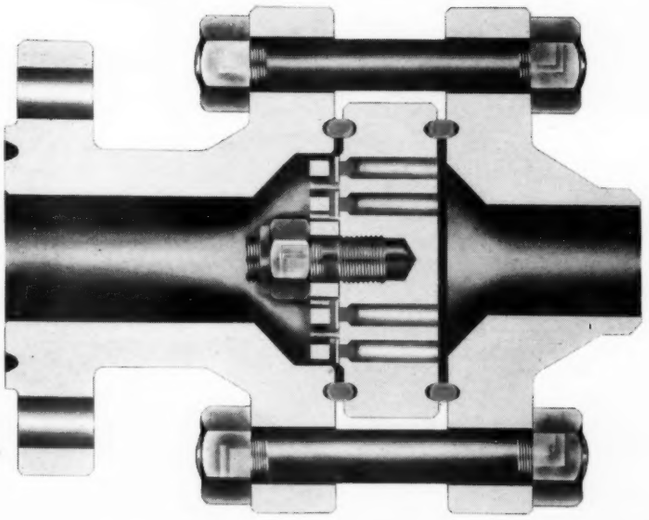
Furnished in semi-liquid form for cold application by brush or sling, TecPro builds up a ductile, water-proof covering having high dielectric qualities. The cost for material and labor is slight when compared with the value of the pipe, and a line so treated will last years longer, is less subject to leakage, and the pipe has greater resale value when taken up. TecPro has protected lines of oil and gas companies for years, and its continued use by them is proof of its merit.

TECPRO PROTECTS

Technical Products Incorporated

Manufacturers
DALLAS, TEXAS

Abercrombie WAFER CHECK VALVE



For Gas, Air or Steam

The Abercrombie Type B Wafer Check Valve is filling an important place in high pressure recycling and pressure maintenance plant lines where violent pressure fluctuations occur . . . where a check valve with extremely light moving parts is necessary. This valve definitely will not pound itself out on a single machine, or on single-acting cylinder installations. It is built to 8,000- or 10,000-pound test, and employs API Series 1500 or Series 2500 flanges of the ring joint type. Companion flanges to fit any condition are also available. The valve has full opening seats and is available in sizes up to 8⅝" O. D. line.

For full details write Abercrombie Pump Company, Gulf Building, Houston, Texas.

FLUID-PISTON SLUSH PUMPS

ABERCROMBIE PUMP CO.

but reduced to 256 r.p.m. by a vertical-shaft speed-reduction gear.

Coolers and Condensers

All plant process cooling and condensing duties are performed in sections situated beneath the induced-draft water-cooling tower. The high-pressure gas on its way to the absorbers is cooled in the same manner, the cooling sections being designed for 1500-lb. pressure. Except for these high-pressure gas cooling sections all condensers and coolers are provided with cast pearlitic-iron headers and red brass tubes.

Pumping Equipment

Pumps used in various services throughout the plant are both motor- and steam-driven. Below is a complete listing of the number, size, type, powering unit, and the duties of the different pumps:

High-pressure oil pumps—three 3¼ by 12 forged fluid-end duplex plunger pumps driven through silent chain drives by 100-hp. explosion-proof motors.

Hot-oil pumps — two self-venting, single-stage centrifugal pumps direct-connected to 15-hp. explosion-proof motors.

Still reflux pumps—two centrifugal pumps mounted on the same bed plates with, and close-coupled to, 7½-hp. explosion-proof motors.

Jacket-water pumps—two single-stage centrifugal pumps direct-connected to 75-hp. motors.

Cooling tower circulating water pumps — two single-stage centrifugal pumps direct-connected to 60-hp. motors.

Stabilizer charge pump—a 14 by 8½ by 18 close-clearance-type, simplex piston-pattern steam pump.

Stabilizer spare pump—a 16 by 10 by 18 close-clearance-type, simplex piston-pattern steam pump.

Stabilizer reflux pump—an 8 by 10 by 18 close-clearance-type simplex piston-pattern steam pump.

General utility pump, condensate pumps—three 6 by 4 by 6 duplex piston-pattern steam pumps.

Boiler feed pumps—two 7½ by 4½ by 10 duplex plunger-pattern steam pumps.

Distillate reflux pumps — two centrifugal pumps close-coupled to 3-hp. explosion-proof motors.

Reclaiming oil-circulating pump—a self-venting, single-stage centrifugal pump direct-connected to a 3-hp. explosion-proof motor.

Reclaimed-oil-to-system pump—a 3½ by 3½ by 4, all-iron-fitted simplex piston-pattern steam pump.

Water supply pump—a deep-well centrifugal pump driven by a 30-hp. vertical weather-proof motor. This pump delivers make-up water from a well bored in the plant property.

Shipping pump—a 5 by 10, side-pot, duplex pump driven through V-belts by a 75-hp. explosion-proof motor.

Steam Generation

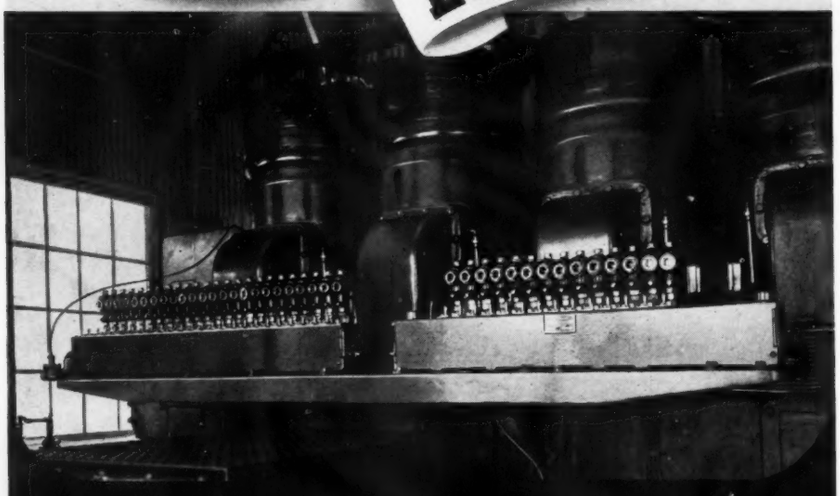
Steam is generated by four 125-hp. oil-field type boilers operated at a pressure of 250 lb. Each boiler is equipped with four intermediate pressure burners, water gauge columns, high and low level alarm, and feedwater regulator. Boiler feed pumps consist of two 7½ by 4½ by 10, outside-packed, duplex reciprocating pumps. All steam lines are insulated and are carried overhead. Boiler feedwater is pumped from a 2000-bbl. tank, which in turn receives its supply from a water well drilled on the plant property.

Water Circulation System

All make-up to the jacket-water system is condensed steam. The system is closed except for a hot well. Water

Clark Engine's . . . Coastal Recycling Plant

McCORD LUBRICATOR EQUIPPED



McCord lubricators were selected for the largest high pressure absorption plant because years of service in the oil and gas fields had proven that for design, accuracy, and dependability McCord Lubricators are unsurpassed. McCord lubricators maintain an unceasing guard on the reliability and service that Clark builds into engines.

McCORD RADIATOR & MFG. CO. • DETROIT, MICHIGAN

McCORD FORCE FEED LUBRICATORS

STANDARD OF THE OIL FIELDS

from the hot well is pumped through the atmospheric sections in the cooling tower, thence to a 600-bbl. capacity elevated tank, and to the jackets of the compressor engines and convertible gas-Diesel engines that drive the generator units. Water from the engine jackets returns to the hot well for recirculation.

To pump water to the engine jackets two single-stage centrifugal pumps direct-connected to 75-hp. motors are employed. Two single-stage centrifugal pumps direct-connected to 60-hp. motors are used to circulate water over the cooling tower.

Automatic Controls

Automatic controls are provided on all important operations throughout the plant. The absorbers are equipped with internal-type liquid-level controllers designed for a working pressure of 1500 lb. The controllers are fitted with high-pressure ball floats to avoid collapsing at the pressures they encounter inside the absorbers.

On these high-pressure absorbers, the high-level compressor shut-down is obtained through the operation of a special two-way, quick-acting pilot. An identical installation is on the recompressor vapor stop tank level controller. The function of these level controllers is to shut-down the compressors in event the level in the vessels becomes too high, thus preventing damage to the compressor units. Purposely, a quick-acting pilot is used so that there will be no throttling action, but a complete and immediate shut-down of the compressor units in the event of such high levels.

Liquid-level controllers are found also in the following applications: low-pressure vent tank, high-pressure vent tank, kerosine distillate still, kerosine distillate accumulator, stabilizer column, stabilizer reflux accumulator, and reclaiming oil accumulator. These are all of the high-pressure column type.

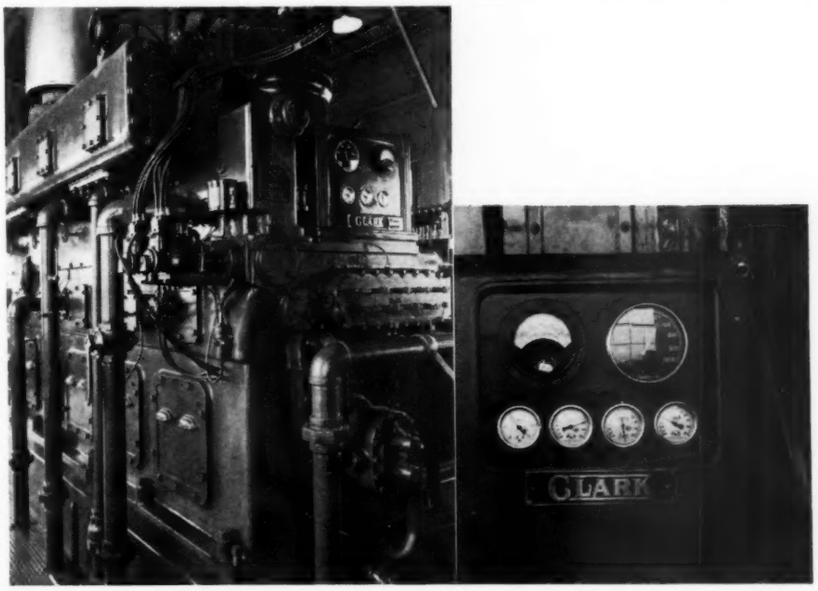
To control the pressure on the fuel supply to the recompressors, generator units, boilers, and heaters a regulator of the gas-balance type is used. As a safety provision, two valves are installed on the fuel line ahead of the fuel gas regulator. One valve takes its control points from the downstream side of the gas-pressure regulator and closes-off the flow of gas in the event of loss of pressure in the fuel line. The other valve is so arranged that with an increase of pressure on the diaphragm it will unlatch and close-off.

The regulators for maintaining plant pressures are pressure-reducing valves or back-pressure regulators. These are placed on the plant intake lines and serve to maintain a pressure on the absorbers of 1500 lb. per sq. in. and prevent overpressure from being placed on the plant.

Recording and Controlling Instruments

The streamlined rectangular case recorders and controllers, for pressure, flow, and temperature applications in the plant, are especially well adapted to the flush-type board mounting used, in that only one hole need be cut in the panel for any instrument. All cases are identical, whether recorders or controllers, and regardless of the service. The cases have concealed hinges, and a cam-action door handle and lock insures a tight sponge-gasket seal. The baked-enamel finish is resistant to atmospheres containing salt, moisture, and acids.

Control units are identical for each controller whether flow, pressure, or temperature. The throttling range and automatic reset adjustments can be made instantly, externally to the chart plate, during operation without upsetting either the control or the process. The instrument is completely sealed against corrosion and dirt and is self-compensating for ambient temperatures.



"ALNOR" EXHAUST PYROMETERS

PROTECT CLARK ENGINES

At Coastal Recycling Plant, Agua Dulce, Texas

In this outstanding plant of the Coastal Recycling Company, 5 Clark 2-cycle engines of 800 hp. each and 3 Clark 4-cycle 400 hp. convertible engines are installed.

Each engine is equipped and protected by an "Alnor" round flush type exhaust Pyrometer to aid the engineers in keeping the engines operating at top-notch efficiency and maximum economy. With the "Alnors" the combustion conditions of each cylinder of each engine can be checked quickly and maladjustments avoided.

This type of Pyrometer is only one of many styles offered in the "Alnor" line. There is a type and size suited for every make of Diesel or gas engine regardless of size or horse-power.

It will pay you to insist that your engines be "Alnor" equipped.

For complete information ask for catalog

ILLINOIS TESTING LABORATORIES, Inc.

413 North LaSalle Street Chicago, Illinois

Use "Alnor" Pyrometers, the Engine X-Ray

COASTAL RECYCLING

SECTIONAL STEEL

BUILDINGS

Through Stearns-Roger Mfg. Co.

FABRICATED AND ERECTED

By

ALLIED STEEL PRODUCTS CORP.

TULSA, OKLAHOMA

Service From Preliminary Design

To

COMPLETION

ALLIED STEEL PRODUCTS CORP

Also Furnished . .

ALLIED GRATING — FLOOR PLATES

EXHAUST JACKETS — SUPPORTS

COASTAL SELECTS

Vortox Air Cleaners

For World's Largest High-Pressure Absorption and Pressure-Maintenance Plant!

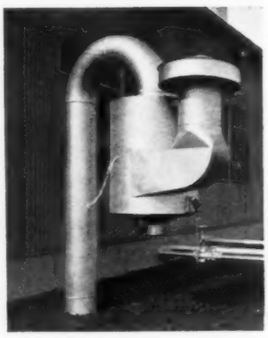
Vortox Air Cleaners are the Popular Choice for Recycling and Repressuring Operations

Because of high dust-removing efficiency and dependable service provided in other installations, Vortox Oil Type Self-Washing Air Cleaners were specified by Coastal Recycling Corporation to completely dust-protect the large gas engines in its new absorption and pressure-maintenance plant at Agua Dulce, Texas. Manufacturers who are now building the special engines for recycling work are recommending the use of Vortox Cleaners as *standard equipment!*

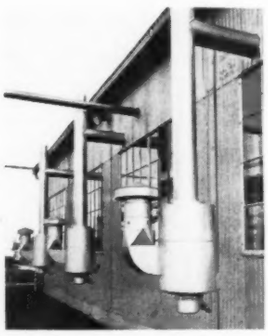
LATEST VORTOX FEATURES

Vortox Air Cleaners used by Coastal incorporate the latest developments in air cleaner design. The units are entirely self-cleaning—eliminating appreciable restriction to air flow . . . and they combine the three most effective air cleaning principles known — centrifugal action, cyclonic oil spray and oil-washed filter elements.

Why not take advantage of the engine maintenance savings made possible with Vortox Air Cleaners? Vortox maintains a specialized engineering service for the solution of *your* particular air cleaning problems. Write for details!



Vortox Cleaner on 800 HP Engine-Compressor Unit—Rectifying Plant.



Vortox Cleaners on Auxiliary Power Plant Engines.

VORTOX MANUFACTURING CO.

CLAREMONT • CALIFORNIA

A new non-bleed, pressure-balanced-type pilot is used in these controllers, the air being exhausted only when the valve pressure is reduced. This construction permits the use of large supply and exhaust ports, capable of extremely fast valve operation, yet keeps air consumption at a minimum. Pressure-balanced construction makes valve response instantaneous and continuous. The pilots are housed in the cases as protection against weather and are the same for all types of controllers.

The 12-in. charts are fastened to the clock drive by a tapered centering and driving stud. The charts are punched to the same time for these studs, making incorrect timing impossible when charts are changed. Knob and chain are eliminated.

Pressure and temperature elements are special alloy-steel, heat-treated flat spirals having overrange protection. All flow meters and controllers have forged-steel mercury chambers, lubricated pressure-tight bearings, check floats, and ground joint U-tube construction. Pen assemblies use a hardened pivot, outboard bearing, and an 8-in. stainless steel pen arm.

Measuring Instruments

Measuring instruments consist of 1500-lb. working pressure flow meters and orifice meters having combination 24-hour and 7-day clocks, as well as 2500-lb.-working-pressure orifice meters and roundcase indicating flow meters, the last for measuring steam.

Buildings

All buildings are of steel-frame, corrugated-galvanized-iron construction. The main compressor building is 140 ft. by 24 ft. by 16 ft.; the building housing the distillation pumps is 40 ft. by 60 ft. by 10 ft.; the building housing the water-circulating pumps, 28 ft. by 36 ft. by 10 ft.; the generator building, 36 ft. by 60 ft. by 16 ft.; the boiler building, 30 ft. by 60 ft. by 16 ft., and the building housing the shipping pump is 16 ft. by 24 ft. by 10 ft. Well-appointed offices and a completely-equipped laboratory are housed in a 26-ft. by 42-ft. by 12-ft. building.

Producing and Key Wells

The producing wells, of which there are 20 connected to the plant at the present time, vary in depth from 4600 ft. to 6900 ft. Production is from the Comstock, Bentonville, and Schroeder formations and bottom-hole pressures vary from 1900 to 3400 lb. Both 5-in. and 7-in. casing strings have been set. Flow, which is through 2- and 2½-in. tubing, is controlled at the wellhead by positive-type chokes.

Residue gas is returned to the producing formations through six key wells, the input pressure approximating the bottom-hole pressure. The input pressure is controlled principally at the plant; however, at each well a means is provided for reducing the pressure in the event a particular well requires less input pressure than that available.

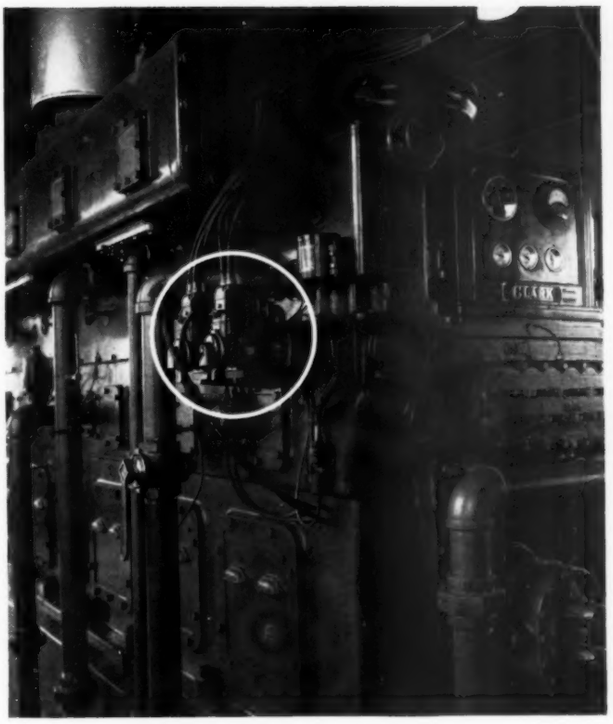
Field Lines

In all main field lines horizontal expansion bends have been installed and in the laterals a vertical bend has been placed at the point where the lateral ties-into the main lines. This latter practice not only allows for expansion but provides a flexible tie-in no matter at what angle the latter "cuts into" the main line. At the wells the lines are securely anchored to a series of concrete blocks.

Field lines, when laid, were all electric welded, and, as protection against corrosion, given two cold coatings and wrapped. The coating used has a high dielectric resistance, is ductile, and impermeable to moisture. The same coating is also used on plant lines. Coating and wrapper were applied by hand.

List of Major Items of Equipment, Including Name of Manufacturer

Absorption oil heaters—Alcorn Combustion Company.
Absorption oil reclamation unit—Stearns-Roger Manufacturing Company.
Absorption oil tanks—Black, Sivalls and Bryson.
Air compressors—Gardner-Denver Company.
Air filters—Vortox Manufacturing Company.
Automatic liquid-level controls—Fisher Governor Company.
Boilers—Oil Well Supply Company.
Boiler burners—John Zink Burner Company.
Boiler water-level controllers—Copes Regulator Company.
Burners on absorption oil heaters—Faber Engineering Company.
Christmas trees on flowing and key wells—Hughes Tool Company
Oil Center Tool Co.
Compressor exhaust silencers—Black, Sivalls and Bryson.
Cooling and condensing equipment—Griscom-Russell Company.
Cooling tower—The Marley Company.
Electric generators and exciters—Westinghouse Electric and Manufacturing Company.
Electric motors, starters, and switches—Westinghouse Electric and Manufacturing Company.
Electric switchboard—Westinghouse Electric and Manufacturing Company.
Elevated water tank—Chicago Bridge and Iron Company.
Engineers and constructors—Stearns-Roger Manufacturing Corporation.
Exhaust pyrometers—Illinois Testing Laboratories, Inc.
Fabricated equipment, such as absorbers, stills, fractionating towers, etc.—Stearns-Roger Manufacturing Company.
Field- and plant-line coating—Technical Products, Inc.
Field-line wrapper—Angier Corporation.
Fire extinguishers—Technical Products, Inc.
Flanges—Taylor Forge and Pipe Works.
Gas compressor units—Clark Brothers Company.
Gas-Diesel convertible engines to drive electric generators—Clark Brothers Company.
Gasoline and kerosine storage tanks—Chicago Bridge and Iron Company.
Gauge glasses—Penberthy Injector Company,
Jerguson Gage and Valve Company.
Heat exchange equipment—Griscom-Russell Company.
Hoists—Yale and Towne.
Industrial-type thermometers — Consolidated Ashcroft Hancock Division of Manning, Maxwell and Moore.
Laboratory equipment—Industrial Scientific Company, C. J. Tagliabue Manufacturing Company, and Precision Scientific Company.
Low tension magnetos—Scintilla Magneto Division, Bendix Aviation Corporation.
Lubricated plug valves—Merco Nordstrom Valve Company.
Lubricating oil pumps—Geo. D. Roper Corporation.
Lubricating oil storage tanks—Wyatt Metal and Boiler Works.
Lubricators—McCord Radiator and Manufacturing Company.
Mercoid safety switches—Scintilla Magneto Division, Bendix Aviation Corporation.
Miscellaneous valves and fittings—Purchased from Continental Supply Company, of Walworth Company and Westcott Valve Company manufacture.
Moisture traps—Crane Company.
Non-return valves from boilers—Edward Valve and Manufacturing Company.
Oilshot system—Bowen Products Corporation.
Orifice meters, indicating and recording flow meters—American Meter Company.
Pipe for field and plant lines—Youngstown Sheet and Tube Company.
Pressure gauges—Consolidated Ashcroft Hancock Division of Manning, Maxwell and Moore.
Pumping equipment—Worthington Pump and Machinery Corp.
Reducing and back-pressure valves—Fisher Governor Company.
Safety valves—Consolidated Ashcroft Hancock Division of Manning, Maxwell and Moore.
Steam traps—Armstrong Machine Works.
Steel buildings—Allied Steel Products Corporation.
Steel fence—Cyclone Fence Company.
Sump pump—Buffalo Pump, Inc.
Temperature, pressure, and flow controls, recording type—Brown Instrument Company.
Wafer check valves—Abercrombie Pump Company.
Water storage tank—Chicago Bridge and Iron Company.
Welding fittings—Tube Turns, Inc.
Welding saddles—Midwest Piping and Supply Company.
Work benches and desk—New Britain Machine Company.



Low Tension Magnetos

FOR Reliability

The Clark Brothers Engines of the Coastal Recycling Corporation Plant, Agua Dulce, Texas, illustrated above, are equipped with Bendix-Scintilla Low Tension Magnetos. See description on page 144 of this issue.

Bendix-Scintilla Low Tension Magnetos are available both as original equipment and for replacement purposes on all makes and types of oil field engines.

SCINTILLA MAGNETO DIVISION
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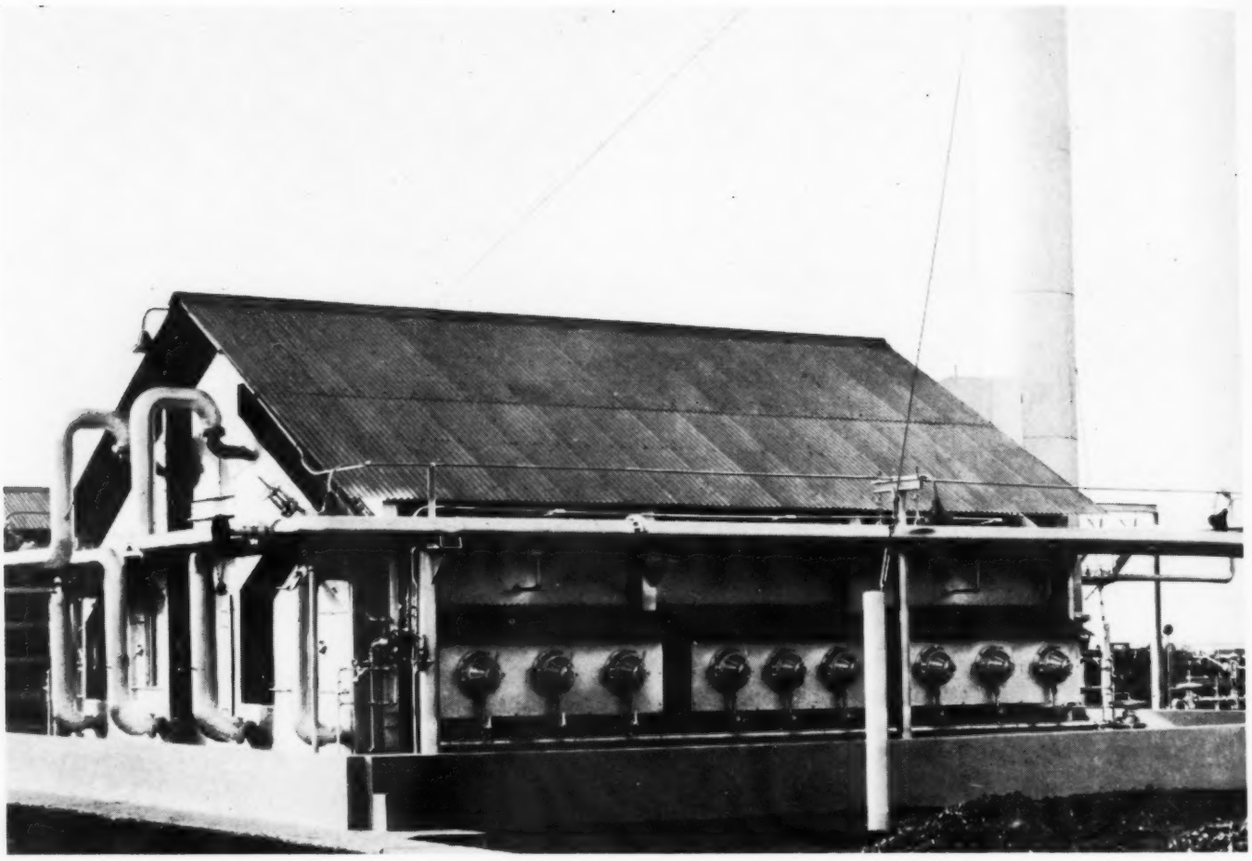

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Deepening and Completing a Well in the Lisbon Field, Louisiana—A Study in Modern Coöperative Practice

Besides applying modern methods of geologic interpretation and of drilling, completion, and testing, the well was studied for possibilities of a pressure-maintenance program for the field and for gasoline recovery—Deepening a well as here described to reach lower potential producing formations is a practice that may hold promise of renewed life to many depleted shallow fields.

Part I

By PAUL D. TORREY, Geologist, The Sloan and Zook Company
and
FRANK H. MILLER, Petroleum Engineer, Lisbon Exploration Company, Inc.

ALTHOUGH this report deals principally with the Lisbon field, reference from time to time will be made to the nearby Sugar Creek field, which, as has been pointed out by Easton,[1] appears to be a semi-connected structural element. The deep tests in the Sugar Creek field are the nearest wells to the Vaughn well that have been drilled to the Lower Marine, or in more specific terms to what is now generally known as the Cotton Valley formation. Such being the case, the records of the deep wells at Sugar Creek have served as a basis for comparison with the record of the Vaughn well, and in consequence the geology of the two fields will be considered together. More detailed and specific information regarding the geology of the Lisbon and Sugar Creek fields may be found in the excellent papers by Grage and Warren,[2] and by Clark.[3] Information from these papers has been freely used in the preparation of this section of the report, and acknowledgment is hereby given for this privilege.

The Lisbon field is situated around the common corner between Ts 20 and 21n, Rs 4 and 5w, Claiborne and Lincoln Parishes, Louisiana, the productive area from the Pettit lime extending into all four townships. The field was discovered in December, 1936, by the completion of E. T. Oakes et al. Patton No. 1, located in the NE ¼ Section 1-20-5. The present productive area of the field comprises some 6500 acres.

The Sugar Creek field is principally in the northwestern part of T19n R5w, Claiborne Parish, Louisiana, although production extends for a short distance into the northeast corner of T19n R6w, and into the southwest corner of T20n R5w. Commercial gas production was first discovered in March, 1930, by the completion of Triangle Drilling Company's Kilpatrick No. 1. The present productive area of the field comprises about 3500 acres.

The production from the Lisbon field is entirely oil, whereas Sugar Creek is principally a gas-producing field having a few oil wells located on the lower flanks of the structure.

From the standpoint of regional geology the Lisbon and Sugar Creek

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FRANK H. MILLER

received his degree in petroleum production engineering from the University of Texas in June, 1939—Prior to attending the university he studied in the Houston Public Schools and in the University of Houston, Houston, Texas —Became associated in the capacity of petroleum engineer in August, 1939, with Lisbon Exploration Company, Inc., the coöperative body formed to drill the well herein described.

[1] Easton, H. D., Personal Communication.

[2] "Lisbon Oil Field, Claiborne and Lincoln Parishes, Louisiana," by V. P. Grage and E. F. Warren. *Bulletin A.A.P.G.*, Vol. 23, No. 3, March, 1939, pp. 281-324.

[3] "Sugar Creek Field, Claiborne Parish, Louisiana," by C. C. Clark. *Bulletin A.A.P.G.*, Vol. 22, No. 1, November, 1938, pp. 1504-18.

fields are located on the eastern flank of a prominent structural feature known as the North Louisiana syncline. The axis of this syncline trends approximately due north from the western part of Bienville Parish into the eastern part of Webster Parish. Important productive structures such as Cotton Valley, Bellvue, and Sligo are on the west flank of the syncline, and fields such as Sugar Creek, Lisbon, and Homer are on the east flank. The Shongaloo and Haynesville fields are near the northern end of the syncline.

The rocks outcropping in the Lisbon-Sugar Creek area belong to the lower part of the Cockfield formation and the upper part of the Cook Mountain formation. The distribution of the outcrop of these formations is somewhat indicative of structural deformation. This is particularly true in the Sugar Creek field, which topographically is in the form of a bowl with soft sands of the Cook Mountain occurring in the center, surrounded by hills capped by the harder sands of the Cockfield. Both fields are located in the drainage system of the Ouachita River, and they are separated by the valley of Bayou D'Arbonne.

1. Stratigraphy of the Eocene, Upper Cretaceous, and Glen Rose formations. The Eocene rocks encountered in the drilling of wells in the Lisbon and Sugar Creek fields are listed in the accompanying generalized section of formations.

The average total thickness of the Eocene rocks in the Lisbon field is 2060 ft., and in the Sugar Creek field the average total thickness of the same section is 1990 ft. A prominent unconformity occurs at the base of the Midway formation.

The Tokio formation is regarded as being the shore line phase of the Austin chalk. The Center Point formation according to Hazzard[4] represents a transitional phase of deposition that grades into fossiliferous Eagle Ford shale going down dip, and merges up dip into what is known as the Woodbine formation in southwest Arkansas. The Upper Cretaceous rocks in the Lisbon field have an average thickness of 1430 ft., and in Sugar Creek field they have an average thickness of 1535 ft. A prominent unconformity occurs at the base of the Center Point formation. No commercial production of oil or gas has been discovered in Upper Cretaceous formations in either the Lisbon or Sugar Creek fields, although some "shows" have been reported.

Directly underlying the Center Point formation in the Lisbon and Sugar Creek fields are rocks of Lower Cretaceous or Comanche age, belonging to what is known as the Trinity Group. These formations are of particular importance inasmuch as certain of their members are the oil and gas reservoirs of the two fields.

In northern Louisiana the Trinity Group is made up of the Glen Rose Sub-Group, which has several separate members, and the Travis Peak formation. Consideration at this point will be given only to the Glen Rose Sub-Group, with a description of the Travis Peak to follow in that part of the article devoted to the formations encountered in the Vaughn well.

The uppermost member of the Glen Rose Sub-Group is the Paluxy formation. The Paluxy is well-developed in the Rodessa field and in other parts of northwestern Louisiana, but is not present in the Lisbon or Sugar Creek fields, having been removed, if ever present, during the period of erosion prior to the deposition of the Center Point formation.

Immediately below the Paluxy is the Upper Glen Rose member. This is the first formation encountered below the Center Point in the Lisbon and Sugar Creek fields. It has been divided further by Clark[5] into the Post-Glen Rose "reds" and the Upper Glen Rose formation proper. In the Sugar Creek field the Post-Glen Rose "reds" have a thickness of from 175 to 225 ft., and consist of a series of limestone, sandy limestone, dark gray shale, and red shale. The Upper Glen Rose formation, as restricted by Clark in the Sugar Creek field, is composed of dark gray, calcareous shale and limestone, and has an average thickness of about 175 ft.

In the Lisbon field the Upper Glen Rose formation has been separated into three members, the upper part of the top member being equivalent presumably to the Post-Glen Rose "reds" of the Sugar Creek field. A description of these beds, taken from the paper by Grage and Warren,[6] is given in Table 3.

Following the Upper Glen Rose formation in descending order is the Glen Rose Anhydrite. Here again there appears to be some difference in opinion as to the stratigraphic boundaries of this member, as well as of certain of the members above and below it. In order to eliminate any possibility of confusion in distinguishing these various members an approximate correlation between the Lisbon and Sugar Creek fields is given in Table 4.

The differences in nomenclature between these Lower Cretaceous formations in the Lisbon and Sugar Creek fields should be apparent from the foregoing tabulation. In the Sugar Creek field the Upper Glen Rose formation has been restricted to an approximately equivalent section in the Lisbon field that is represented by the lower part of the top member of the Upper Glen Rose. In the Sugar Creek field the entire section of beds carrying anhydrite has been designated as the Glen Rose Anhydrite Zone, whereas in the Lisbon field this same section includes the lower two members of the Upper Glen Rose formation: the Glen Rose Anhydrite, or as it is many times

Foreword

This is the story of a well, and from the standpoint of the operators in the Lisbon field, Claiborne and Lincoln Parishes, Louisiana, a very interesting and most important well. The drilling of the Roberta Vaughn No. 1 represents an outstanding example of cooperative enterprise.

This account was originally prepared in the form of a report for the Lisbon Exploration Company, Inc., in order to provide the basis for an orderly development of the only discovery in 1939 for North Louisiana. Subsequently, it appeared that the record of drilling and completion might be of interest to the oil industry, and for that reason the report was somewhat adjusted to its present form.

The article, by definite purpose, differs in many respects from the average engineering report, which usually is restricted to some specific operation or apparatus. It is by no means a specific study of drilling, completion, or production practice, but it is rather a descriptive narration of some of the significant incidents and operations connected with one particular project. Little emphasis has been placed on theoretical considerations; detailed attention has been devoted to performance, and to the many other factors that may assist in the more economical drilling and completion of other deep wells, and the more effective production of oil and gas.

Incidental thereto, but nevertheless intimately related to this account is a discussion of the geology of the area. C. C. Clark of the Union Producing Company and Roy T. Hazzard of the Gulf Refining Company reviewed that part of the article and acknowledgement for their assistance is hereby given.

No attempt has been made to relate the complete story of the organization of Lisbon Exploration Company, Inc., interesting although this is. Passing mention should be made, however, of the fact that this company includes in its list of stockholders virtually all independent operators and royalty owners in the Lisbon field, and also many interested citizens and companies of Claiborne and Lincoln parishes. Substantial support to the enterprise was received from several of the major companies owning properties in the Lisbon field. The company was organized for the specific purpose of exploring the productive possibilities of the rocks occurring below the Glen Rose formation of Lower Cretaceous age.

This article is divided into five parts: (1) Geology, (2) Drilling, (3) Completion, (4) Production Tests, and (5) Consideration of Pressure Maintenance, Gasoline Recovery, and Gas Repressuring in the Shallow Producing Horizon.

[4]Hazzard, Roy T., Guide Book, Shreveport Geological Society, 18th Annual Field Trip.

[5]Clark, C. C., previous citation, p. 1509.
[6]Grage and Warren, previous citation, p. 292.

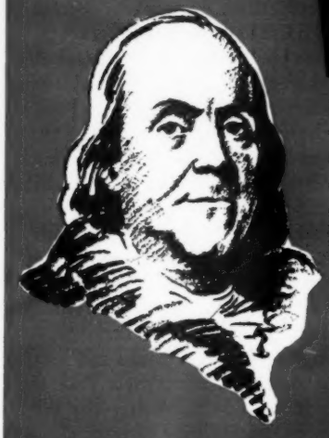

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TABLE 1

Description of Eocene formations in the Lisbon and Sugar Creek fields.

Name of Formation	Average thickness — ft. in Lisbon field	Average thickness — ft. in Sugar Creek field	Description
Cockfield	0	20	Lignitic, yellowish-brown, sands and clays.
Cook Mountain	275	250	Reddish weathering, ferruginous sands and clays with numerous hard, discontinuous ironstone ledges.
Sparta	550	425	Non-marine, unconsolidated, lignitic, grayish white sands with a few dark gray beds of shale.
Cane River	170	185	Marine, gray and brown fossiliferous sandy clays, glauconitic sands, and some calcareous clay.
Wilcox	630	525	Brown and gray shale, sandy shale, and cross-bedded lignitic sands, with claystone boulders throughout.
Midway	435	585	Dark gray to black shale, lower part calcareous.

TABLE 2

Description of Upper Cretaceous formations in the Lisbon and Sugar Creek fields.

Name	Average thickness — ft. in Lisbon field	Average thickness — ft. in Sugar Creek field	Description
Arkadelphia	100	35	Fossiliferous, gray calcareous shale and chalk.
Nacatosh	175	200	Sandy, fossiliferous limestones and soft porous sands in upper part. Dark, calcareous, fossiliferous shales in lower part.
Saratoga	30	30	Hard, gray and white fossiliferous chalk with thin beds of calcareous shale.
Marlbrook	160	200	Fossiliferous, gray calcareous shale and marl.
Annona	50	50	Hard, white and gray fossiliferous chalk.
Ozan	210	230	Dark gray, sandy, calcareous shales, with thin beds of sand.
Buckrange	90	40	Medium to coarse-grained porous sand.
Brownstown-Tokio	490	650	Brownstown predominately made up of calcareous gray and brown shales with thin limestone shells. Tokio consists of gray sands and sandy shales.
Center Point Volcanics or Woodbine(?)	125	100	Red shales and sandy shales composed largely of residual volcanic material.

called, the "Massive" Anhydrite, and the upper beds of the Rodessa formation. The total thickness of this series of rocks is quite uniform, the difference between the two fields amounting to only a few feet.

The Glen Rose Anhydrite in the Lisbon field has an average thickness of 200 ft. and is composed of milky to gray anhydrite with interbedded streaks of black, calcareous shale. In the Sugar Creek field this same bed has a maximum thickness of 235 ft. and possesses the same lithologic characteristics. Owing to its persistency and ease of identification from drill cuttings and on electrical logs, the base of the Glen Rose Anhydrite, as restricted in the Lisbon field, has become a favorite horizon for subsurface structural mapping.

Adhering to the nomenclature of the Lisbon field, below the Glen Rose Anhydrite comes the Rodessa member, which in turn lies directly above the Pine Island member, these two members constituting the Lower Glen Rose formation. As has been previously noted, in the Sugar Creek field the Lower Glen Rose includes all of the beds below the Anhydrite "Stringer" down to the top of the Travis Peak formation, with the recognition of the presence of a transitional zone between the marine beds of the Glen Rose and the non-marine beds of the Travis Peak.

Grage and Warren[7] have given a very good description of the beds making up the Lower Glen Rose formation in their paper on the Lisbon field. This description is reproduced in Table 5 with a few minor alterations.

The Patton zone or Pettit lime is not developed in the Sugar Creek field. It has been correlated with the Pettit of the Sligo and Shreveport fields.

The lowest beds of the Pine Island member in the Lisbon field are correlated with the transitional zone between the Glen Rose and Travis Peak in the Sugar Creek field.

The thickness of the Lower Glen Rose formation in the Lisbon field varies from 1125 to 1225 ft., the average thickness being 1175 ft. The equivalent beds in the Sugar Creek field have an average thickness of about 1250 ft.

The drillers' record of the formations encountered in the drilling of the Roberta Vaughn No. 1 well from the top of the ground down through the Pettit lime is given in Appendix 1, at the end of this report. This record is not sufficiently complete to enable the recognition of all of the formations penetrated, but it does indicate some of the more noticeable characteristics of the Eocene, Upper Cretaceous, and Glen Rose rocks.

2. Stratigraphy of the Travis Peak and Cotton Valley formations. The description of the Travis Peak and the upper part of the Cotton Valley formations is separated from that of the overlying formations for the reason that they were actually drilled during the course of deepening the Vaughn well. A detailed record was kept of these formations and made possible a thorough study of their character. It should be mentioned at this point that the Roberta Vaughn No. 1 well was originally completed as a producer from the Pettit lime on May 7, 1937. After producing for a period of almost two years it was temporarily abandoned before deepening operations were begun on August 19, 1939. The total depth of the well before it was deepened was 5313 ft. The Pettit lime had a thickness of 8 ft., and was found at a depth of 5295 to 5303 ft.

In northwestern Louisiana and southwestern Arkansas the Travis Peak formation is regarded as being the lower member of the Trinity Group. Underlying the Travis Peak comes a series of rocks of Pre-Trinity age, which are, in descending order, the Cotton Valley formation, the Buckner formation, the Smackover limestone, and the Eagle Mills formation. The Cotton Valley is frequently referred to as the Lower Marine formation, and actually until recently was considered to be a lower member of the Travis Peak.

The transition zone between the Lower Glen Rose and the Travis Peak was found at a depth of 5303 to 5394 ft. in the Vaughn well. This section consists of interbedded hard limestones, gray shale, gray sandy shale, and streaks of hard gray sand. The top of the Travis Peak is marked by a hard sandy lime having a thickness of about 10 ft., and the first red beds, so characteristic of this formation, occurring directly below it, were found at a depth of 5405.5 ft.

The Travis Peak beds encountered in the Vaughn well are probably entirely non-marine except for one thin member in the upper part, and for the very

[7]Grage and Warren, previous citation, p. 289.

lowest part, the latter having an aggregate thickness of 230 ft. and possibly representing a transition zone. As such, the Travis Peak is undoubtedly most inconsistent in the regularity of its individual beds, as it is elsewhere, but from an examination of the formation and electrical logs it is apparent that several distinct zones or series of sediments can be recognized.

Comparisons between the record of the Travis Peak in the Vaughn well and the two deep test wells in the Sugar Creek field, the Darrett No. 2 and the Brownfield No. 2, are none too satisfactory. To a great extent the same applies to attempted correlations of the records of these two wells, notwithstanding their proximity to each other. There are several reasons for this condition. A very careful formation record was kept of the Travis Peak and Cotton Valley formations in the Darrett well. In contrast thereto the formation record of the Brownfield well is very limited. Another complicating factor is introduced by the fact that the Darrett well was drilled very close to a fault, and probably actually cut the fault plane between the base of the Annona Chalk and the base of the Massive Anhydrite. Such being the case, a distorted thickness of certain of the beds might naturally be expected. Then, too, the Travis Peak formation seems to be consistently irregular, there being a variation in thickness in the Cotton Valley field of about 400 ft. These various complications, when combined, make it readily understandable why it is impossible to correlate accurately the formation records of the Darrett and the Brownfield wells, notwithstanding the fact that they are situated only about a mile apart. The same complications are doubtless amplified when an attempt is made to correlate the records of these two wells with the record of the Vaughn well, the Vaughn well being separated from the Brownfield well by a linear distance of about 8½ miles. (See Fig. 2.)

Although the formation record of the Brownfield well was not kept in any great detail, the record in its principal features is fairly reliable and as such is more frequently employed as a basis for comparison. Several electrical surveys were made of the Brownfield well, and the record of these surveys has been available for comparison with the electrical logs of the Vaughn well.

In Table 6, the various distinguishable beds of the Travis Peak formation encountered in the Vaughn well have been separated into units based upon lithology, drilling characteristics, and electrical properties. The detailed record of the Travis Peak will be found in Appendix 2 at the end of the report.

The total thickness of the Travis Peak formation, as here designated, is 2666 ft. Certain of the sands occurring in Unit 1 very likely are gas-bearing, and will be described in greater detail in a following section of this report. The transitional zone between the Lower Glen Rose and the Travis Peak, and the upper 150 to 200 ft. of Unit 1 in all probability corresponds to the Darrett producing zone in the Sugar Creek field.

Attention should be called to the thin marine section encountered at a depth of 5955 to 5965 ft. The marine character of this bed is indicated by megascopic fossil shell fragments. It is quite posssible that a careful microscopic examination of drill cuttings might reveal other marine horizons, inasmuch as a marine wedge, consisting of fossiliferous, black shale and dark shaly limestones, is reported to

TABLE 3

Thickness and description of Upper Glen Rose formation in the Lisbon field.

Description	*Average thickness, ft.*
1—Red sandy shales and fine-grained sands grading downward into black, calcareous shales with thin-bedded, fossiliferous limestones. Variation in thickness due to erosional truncation with greater thickness on south side of field	180-415
2—Interbedded black shales and thin limestones with three thin anhydrite stringers from 5 to 15 ft. in thickness. Anhydrite stringers are lenticular and are not everywhere developed	65
3—Fossiliferous, black calcareous shales with thin interbedded limestones	140
Total thickness of section, from 385 to 620 ft.	

TABLE 4

Correlation between certain of the formations and members of the Glen Rose Sub-Group in the Lisbon and Sugar Creek fields.

Lisbon Field		*Sugar Creek Field*
Upper Glen Rose	Red sandy shale series with black calcareous shales and fossiliferous limestone in lower part	Post Glen Rose "reds"
		Upper Glen Rose formation
	Black shale and limestone with anhydrite stringers	
	Fossiliferous black shales with thin interbedded limestones	
Glen Rose Anhydrite		Glen Rose Anhydrite Zone
Rodessa Member down to the base of the first anhydrite stringer below the "Massive" or Glen Rose Anhydrite		

TABLE 5

Description and average thickness of Lower Glen Rose members in the Lisbon field.

Description of Beds	*Average thickness, ft.*
Rodessa Member (630 to 680 ft. in total thickness)	
Slightly porous, oölitic and fossiliferous gray limestones, and thin interbedded dark shales. Small showings of oil and gas. These beds are known as the Kilpatrick productive zone in the Sugar Creek field, and also have produced in the Cotton Valley field	35
Dark, calcareous shale	50
Anhydrite (first stringer below "massive") with interbedded shales	35
Reddish-brown and gray sandy shales and fine-grained sandstones	120-170
Dark calcareous shales and thin-bedded limestones	65
Porous, sandy limestones	90
Dark, calcareous shales and thin-bedded, gray fossiliferous limestones	165
Porous, sandy, oölitic, coquina-type limestone known as the "James Zone." The James Zone is regarded as being equivalent to the oil- and gas-producing "Dees and Young Zones" of the Rodessa field	70
Pine Island Member (495-545 ft. in total thickness)	
Dark, fossiliferous, calcareous shales	270
Porous limestones	20
Dark shales	40
Argillaceous, fossiliferous limestone and interbedded shales. This is known as the "Three-Fingered Limestone" on account of its appearance on electrical logs. It is a very persistent horizon in the Lisbon and Sugar Creek fields	45
Dark, calcareous shales	50
Argillaceous, porous, oölitic, fossiliferous, sandy limestone. This is the Pettit lime or Patton zone, and is the upper productive horizon of the Lisbon field	0-20
Argillaceous limestones, oölitic in part, dark shales with local development of fine-grained lignitic, salt water-bearing sandstone	70-100

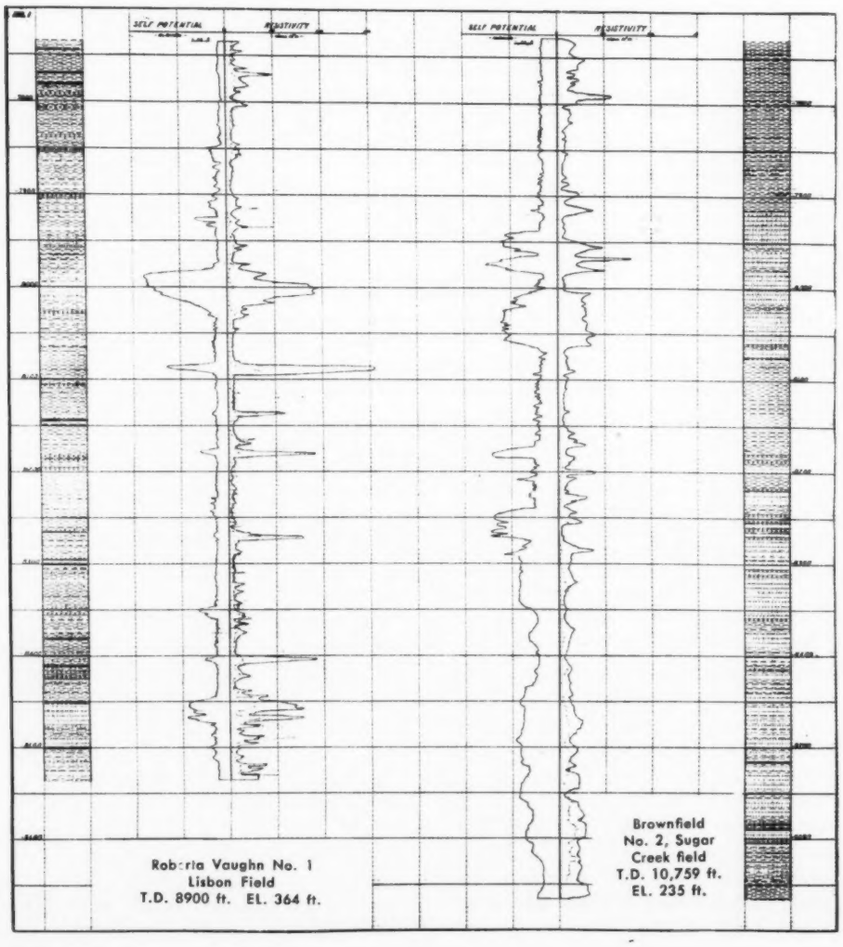
After Grage and Warren

TABLE 6

Abridged record of the Travis Peak formation as encountered in the Roberta Vaughn No. 1 well.

Unit	Depth, ft.	Thickness, ft.	Description
1	5394-6290	896	Alternating red and gray shale and sandy shale, prominent white and gray sands, and a few streaks of lignite. Thin, probably marine, section indicated from 5955 to 5965 ft.
2	6290-6570	280	Predominately red and gray shale and sandy shale with a few thin white sand streaks, and a little lignite.
3	6570-6810	240	Alternating red and gray shale and sandy shale, and white and gray sands.
4	6810-7220	410	Predominately red sandy shale, with a little gray and green shale, and a few thin streaks of red and white sand.
5	7220-7410	190	Fairly hard red and white sands with some red sandy shale, and a little gray shale.
6	7410-7590	180	Hard, white, gray, and red sands, and red and gray sandy shales.
7	7590-7830	240	Very hard red, gray, and white sands, red sandy shale, and a little gray shale. Series of extremely hard quartzitic sands interbedded with hard gray and red sandy shales between depths of 7735 and 7780 ft. Thin streak of coal between 7810 and 7820 ft.
8	7830-8060	230	Predominately gray, somewhat calcareous and sparingly fossiliferous, shale with a little brownish-red shale, and a few thin, hard quartzitic sands. These beds may possibly be transitional between the Travis Peak and Cotton Valley formations.

Fig. 1. Geologic and electrical logs of Vaughn and Brownfield wells



exist in the upper part of the Travis Peak in the Sugar Creek field.

During the course of drilling the Vaughn well the base of the Travis Peak formation was thought to be at the top of Unit 8, as herein designated, but subsequently it has appeared more likely that the beds of Unit 8 represent a transitional stage of deposition between the Travis Peak and the Cotton Valley formations. The contact between Units 7 and 8 represents a very decided change in sedimentary type. Below this contact none of the characteristic red shales and sands is found; the beds of Unit 8 appear to be largely marine, whereas those above it possess all of the attributes of continental types of deposits. This provisional determination was later abandoned when black, fossiliferous shales were encountered at a depth of 8060 ft., and after being advised by Hazzard[8] that going down dip in a basinward direction, the Travis Peak interfingers into a continuous marine section. The electrical log of the Vaughn well might indicate the base of the Travis Peak at a depth of 7960 ft., but this point does not correspond to the change in the lithology of the rocks established from the examination of cores and drill cuttings.

In the Brownfield well the top of the Travis Peak is reported to have been encountered at a depth of 5540 ft., and the top of the Cotton Valley formation at 7787 ft., a total thickness of 2247 ft. for the Travis Peak formation. The thickness of the Travis Peak in the Vaughn well being 2666 ft., a southwestward thinning in the amount of 419 ft. is indicated from the Lisbon field to the Sugar Creek field.

The formation record of the Brownfield well is not sufficiently complete to provide a basis for comparison between the various units of the Travis Peak formation, as established from the record of the Vaughn well. From a comparison of the electrical logs of the two wells, a few tentative deductions may be made. Units 1, 2, and 3 in the Vaughn well, having a total thickness of 1416 ft., may correspond to the section in the Brownfield well to a depth of 6980 ft., this section at Sugar Creek having a total thickness of 1560 ft. It is also suggested that Units 4, 5, 6, and 7, having a total thickness of 1020 ft. in the Vaughn well may be equivalent to the remaining lower part of the Travis Peak section in the Brownfield well, having a thickness of 807 ft., and that no equivalent for Unit 8 occurs in the Brownfield well section.

In addition to the variation in thickness of the Travis Peak formation between the Brownfield and the Vaughn

[8]Hazzard, Roy T., personal communication.

PROGRESSIVE MILLING

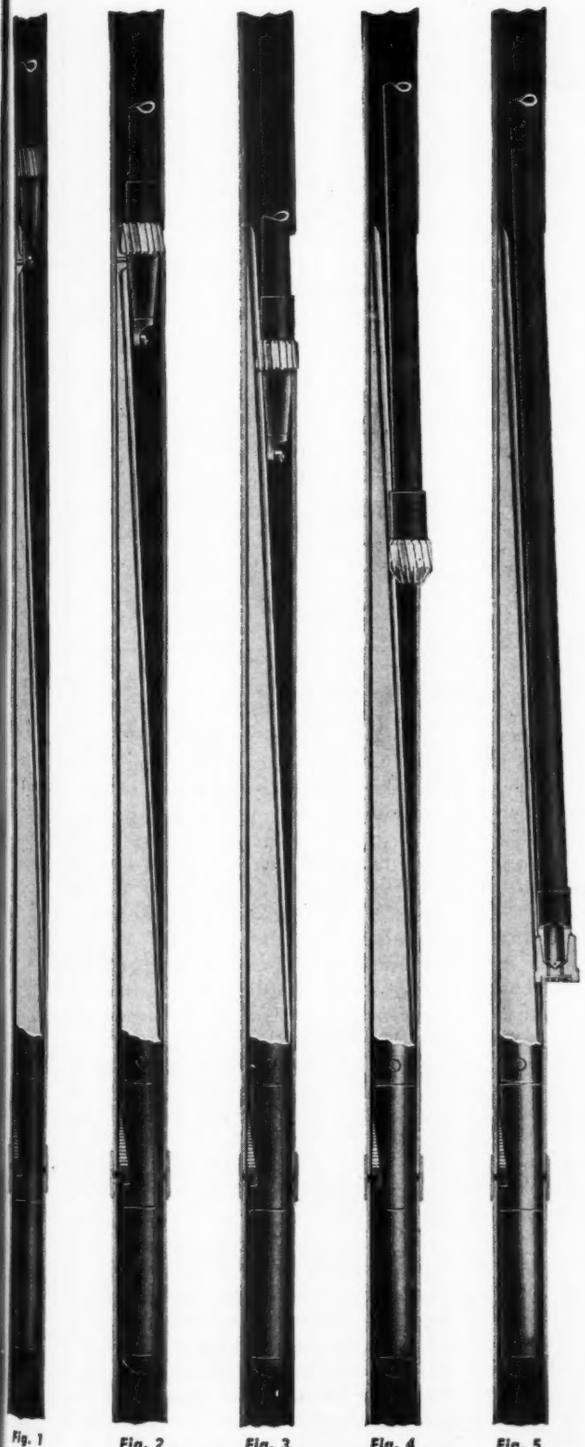


Fig. 1 Fig. 2 Fig. 3 Fig. 4 Fig. 5

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Type "H" Whipstock is the same design as the Kinzbach Type "A" except that Type "H" has the pilot lug added to the top of the concave section.

Fig. 1 shows Whipstock set in casing, setting tool being integral with starting mill (Type "F") and in position to shear loose from Whipstock. After shearing, the pilot on mill engages lug on Whipstock, forcing mill to cut through pipe wall by contact with taper on pilot of mill without permitting mill to cut Whipstock.

After body of mill reaches lug on Whipstock (Fig. 2), pilot takes up space between lug and inner pipe wall, forcing mill to cut off lug, which is no longer necessary. The pilot mill may then be run for some distance below the lug (Fig. 3); then removed from hole.

Type "A" mill is used next in the progression of tools (Fig. 4), running from the point where pilot mill was removed. The window may be finished with this type tool unless difficulty is encountered in holding it in to cut out bottom section of window.

For maximum length of window it will be necessary to use Type "E" mill for the last operation (Fig. 5). This mill cuts a short core, which is in turn milled up by the inserts. This core serves to hold mill in position against face of Whipstock, and is of such length and shape that a second mill of same type will go directly back to its proper position for a continuation of the cut without interference from the core.

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wells, the large number of sands found in the Lisbon deep test, which do not occur at Sugar Creek, is most significant. This increased thickness in sand section might well account for the greater thickness of the Travis Peak at Lisbon.

The formation record of the Travis Peak as a unit in the Brownfield well indicates that it is made up of red and gray shales and sandy shales, and fine-grained gray and red sandstones. The drillers' record of the Brownfield well particularly emphasizes a very hard section of sands and shales at a depth of 7550 ft. to about 7750 ft., an interval of 200 ft. When this particular section is graphically compared with Unit 7 of the Travis Peak in the Vaughn well it can be seen that there is a fairly exact correlation between the individual hard beds encountered in both of the wells. As black shales, according to Clark,[9] were found in the Brownfield well at a depth of 7790 ft., the foregoing evidence would tend to support the conclusion that Unit 8 in the record of the Vaughn well is for the greater part or entirely missing in the Sugar Creek field.

The entire section of the Cotton Valley or "Lower Marine" formation was not penetrated by the Vaughn well. The estimated thickness of this formation in the Sugar Creek field is 2628 ft., with the possibility that the lower 110 ft. of this section may belong to the Buckner formation. It is believed that a total of 840 ft. of the Cotton Valley formation was drilled in the Lisbon deep test. A very careful record was kept of all beds drilled.

In order to illustrate better some of the significant differences between the upper part of the Cotton Valley formation in the Lisbon and Sugar Creek fields, the formation and electrical logs of the Vaughn and Brownfield wells have been graphically plotted in Fig. 1. The comparison of the electrical logs is of particular interest inasmuch as these records, when originally prepared, were on different horizontal scales, which resulted in a somewhat misleading impression of their electrical properties. In order to give some idea of the structural relation between the two wells, all depth points were changed to sub-sea datum elevations.

A detailed formation record of that part of the Cotton Valley drilled in the Vaughn well will be found in Appendix 2 at the end of this report. An abridged record, similar to that presented for the Travis Peak formation, will be found in Table 7. The record of the Cotton Valley and other lower Pre-Trinity formations encountered in the Brownfield well is given in Table 8.

It is apparent, even from a cursory inspection of Fig. 1, that it is clearly impossible to correlate exactly the various beds of the Cotton Valley formation between the Vaughn and Brownfield wells. The section beginning at a depth of 8094 ft. in the Brownfield well may correspond to the section beginning at 8220 ft. in the Vaughn well. These points represent the highest sands and sandy shales in the Cotton Valley formation. It is significant that the sands in the Brownfield well are much better developed than are those found in the Vaughn well. Assuming the correctness of the depths just mentioned, as the beginnings of the sand section in each well, the Vaughn well had a maximum of only 107 ft. of sandstone, whereas in the Brownfield well, to the equivalent depth of 8785 ft., a total sand section of 320 ft. was encountered, and below this point there are at least 50 ft. more of sands. Actually, therefore, the Vaughn well, for comparable depths, encountered only one-third of the sand section that was found at Sugar Creek in the Brownfield well. Of the total 107 ft. of sand recorded in the Vaughn well it is very probable that not more than 60 or 70 ft. possesses any appreciable porosity. Apparently hard, thin sand bodies and sandy shales were encountered in the Vaughn well at the same comparative horizons at which well-developed sand bodies were found in the Brownfield well.

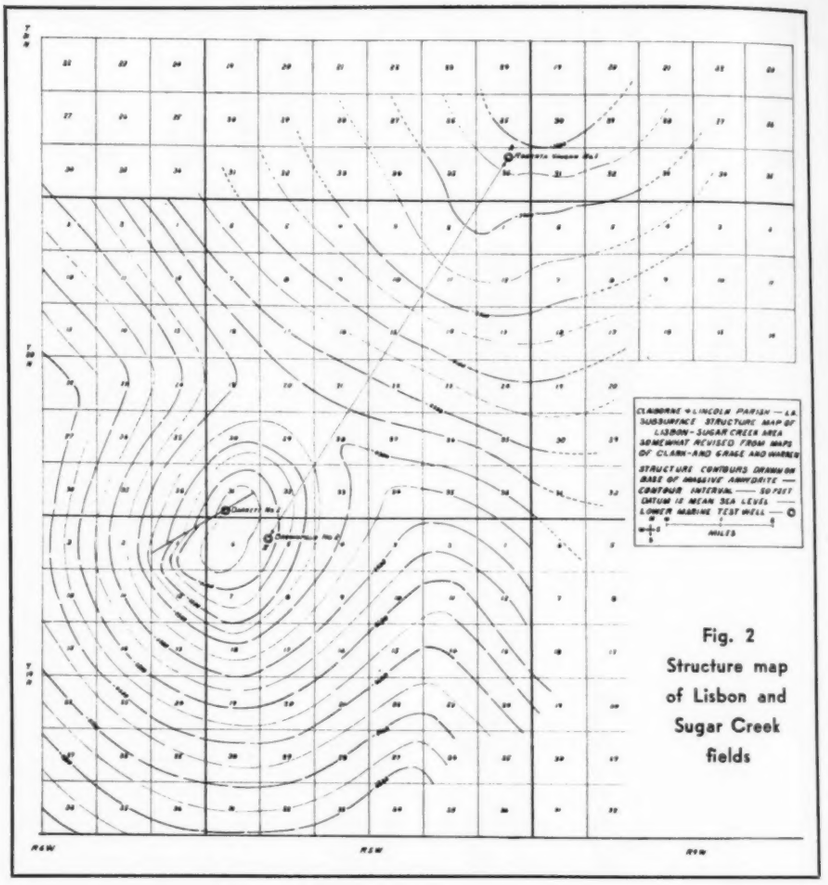


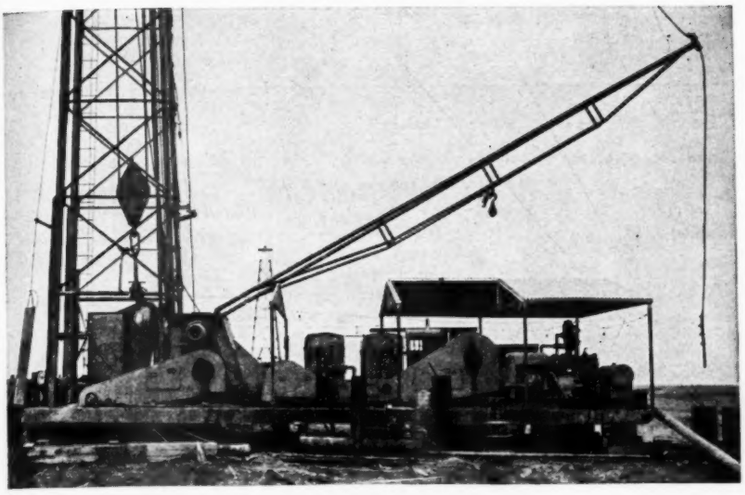
Fig. 2
Structure map of Lisbon and Sugar Creek fields

3. Structural geology. As previously mentioned, surface structure in the Lisbon-Sugar Creek area is indicated by the distribution of the outcrops of the Cockfield and Cook Mountain formations. It is quite likely that the locations of many of the earlier wells in the area were based upon the discovery of evidence of surface structure. Little more than generalized information regarding the subsurface structure of the area was available until commercial production was developed from the Glen Rose and Travis Peak formations in the Sugar Creek field, and from the Glen Rose in the Lisbon field.

In order to present a unified picture of the subsurface structure of the two fields a structure map of the Sugar Creek field, prepared by Clark[10], has been combined with a structure map of the Lisbon field by Grage and Warren[11], the contouring in the Lisbon area being somewhat expanded to reflect additional data now available. (Fig. 2) Structure contours are drawn on the base of the Glen Rose or "Massive" Anhydrite. This horizon has been selected as it is common to both fields and is very readily recognized, because

[9]Clark, C. C., previous citation, p. 1518.

[10]Clark, C. C., previous citation, p. 1511.
[11]Grage and Warren, previous citation, p. 302.



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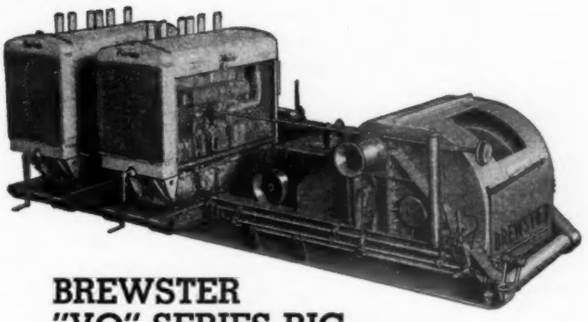

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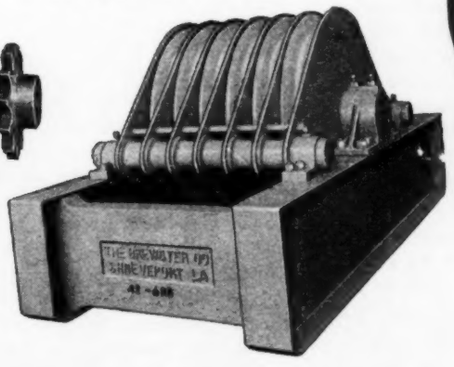

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of the irregularities of both the Kilpatrick and Darrett zones in the Sugar Creek field, and because the Pettit lime of the Lisbon field does not exist as an easily identified unit in the Sugar Creek field.

The structure of the Sugar Creek field is an anticlinal dome having a length of about 4 miles and a width of a little less than 3 miles. The strike of the long axis of the structure is in a northeasterly direction. Closure on the base of the "Massive" Anhydrite amounts to slightly more than 200 ft. The structure is quite symmetrical, being broken at only one point along the northwest flank by a small normal fault, the downthrown side being to the northwest and the upthrown side to the southeast, having a displacement of 20 or 25 ft. The top of the structure is broad and almost level for a distance of about one mile. From the top of the structure the rate of dip to the outside limits of the lowest closing contour is about 160 ft. per mi.

There is definite evidence that the intensity of folding in the Sugar Creek structure increases with depth. The subsurface structure drawn on the base of the Annona Chalk, of Upper Cretaceous age, corresponds quite closely in position to the position of the Lower Cretaceous structure, but has a closure of only 50 ft., and a rate of dip away from the top of 60 ft. per mi. Cores taken from the Cotton Valley and lower formations in the Brownfield well revealed dips of from 7 to 8 degrees that would indicate the structure in these lower rocks may be much more pronounced than it is in the Glen Rose formation.

It is suspected that the Sugar Creek area was a positive element from Pre-Trinity time to at least the end of the Eocene, with succeeding periods of uplift taking place after the deposition of the Cotton Valley formation, at the end of the Lower Cretaceous Period, at the end of the Upper Cretaceous Period, and at the end of the Eocene or some subsequent Tertiary Period. The form of the structure is somewhat suggestive of a deep-seated salt dome, and the different periods of structural deformation may correspond to successive upward movements of a salt mass.

The Sugar Creek structure is separated from the Lisbon field by a shallow syncline that roughly follows the valley of Bayou D'Arbonne, and that strikes in a northwest-southeast direction.

The subsurface structure of the Lisbon field, drawn on the base of the "Massive" Anhydrite, consists of a southwestwardly plunging anticlinal nose having a rate of dip of about 75 ft. to the mile. The extent of production from the Pettit lime appears to be controlled more by the extent of a porous section than by structure, no salt water having ever been discovered in the Pettit even in the lowest wells in the field. It therefore appears that it is little more than a coincidence that the field is located in the structural position that it is.

The subsurface structure of the Lisbon area drawn on the base of the Annona Chalk, of upper Cretaceous age, shows a closure of a little over 25 ft., with dips of from 40 to 50 ft. per mi. away from the top level of the structure in all directions. The subsurface structure on the top of the Pettit lime corresponds quite closely to that on the base of the "Massive" Anhydrite except that the rate of dip of the Pettit structure is somewhat more pronounced, averaging about 100 ft. to the mi.

It has generally been presumed that some structural closure exists in the Lower Cretaceous formations of the Lisbon area, but the present distribution of the wells producing from the Pettit lime prevents the verification of this supposition. It can be definitely established, however, based on the record of the United Gas Company's Meadows No. 1, located in Section 13-21-5, that the top of the Travis Peak formation rises northward beyond the present productive limits of the field. Should closure exist, and taking into account the southward dip from the Meadows well to the Vaughn well, it can be suggested that the structure may possibly be of considerable size, resembling the Sugar Creek structure to the extent of having a broad, fairly flat top and much steeper dips along the flanks. It is believed, however, that such structure as may be present, will not be as pronounced as that found at Sugar Creek, this conclusion being suggested by the fact that no prominent dips were indicated by any of the cores from the Travis Peak and Cotton Valley formations in the Vaughn well.

The subsurface structure of the Cotton Valley formation in the Lisbon area will remain a matter of conjecture until more wells are drilled. Based on the knowledge that the intensity of deformation apparently increases with depth, it would be natural to assume a more pronounced structure in the lower formations. It does appear likely that the structural relations in the lower formations between the Lisbon and Sugar Creek areas may be somewhat different owing to the southwestward convergence of the Travis Peak formation. It might be pointed out further that with the northeasterly lensing-out of the Lower Marine sands, accumulation of oil and gas, such as occurs in the Vaughn sand, might be controlled by the lenticularity of individual beds going up dip rather than to closed structure. To illustrate possible variations in the structure of the Cotton Valley formation from that of the Up-

TABLE 7

Abridged record of the upper part of the Cotton Valley formation as encountered in the Roberta Vaughn No. 1 well.

Unit	*Depth, ft.*	*Thickness, ft.*	*Description*
1	8060-8220	160	Black calcareous shale with fossil shell fragments, and a few thin beds of hard, dove-colored dolomite and dark gray limestone.
2	8220-8351	131	An alternating series of black, calcareous and fossiliferous shales; thin, hard, fine-grained, gray sands in part calcareous; and gray sandy shales.
3	8351-8386	35	Hard, for the greater part porous, gray and brownish-gray, medium-sized to fairly coarse-grained, in some parts calcareous and fossiliferous, thin-bedded sandstone carrying in places asphaltic residue.
4	8386-8426	40	Thin, hard, gray, calcareous sands and sandy shales.
5	8426-8452	26	Black shale.
6	8452-8464	12	Soft, porous, coarse-grained, brown sand. (Vaughn Sand)
7	8464-8637	173	Black, calcareous and fossiliferous shale, with a few thin beds of hard sandy lime and gray limestone.
8	8637-8815	178	Alternating beds of hard gray and white sandstone, with some gray sandy shale, black calcareous and fossiliferous shale, and hard dark gray limestone.
9	8815-8843	28	Hard, partly porous, brownish-gray, fine-grained sandstone with thin, very hard calcareous streaks.
10	8843-8852	9	Gray sandy shale, very hard calcareous sand, and black fossiliferous shale.
11	8852-8860	8	Hard, tight, coarse-grained gray sandstone.
12	8860-8900 TD	40	Black, fossiliferous shale, hard gray sandy shale, and thin beds of hard calcareous sand.

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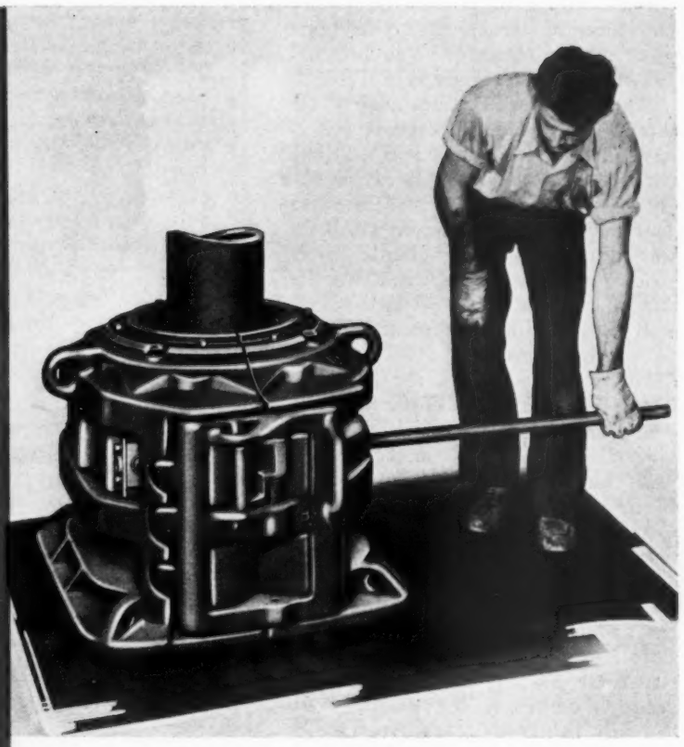

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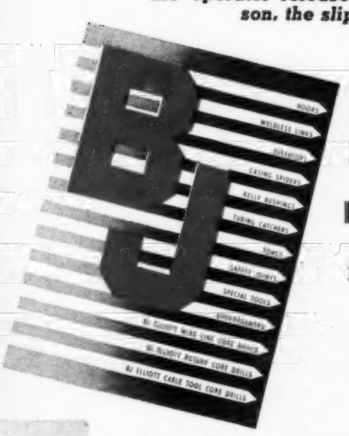

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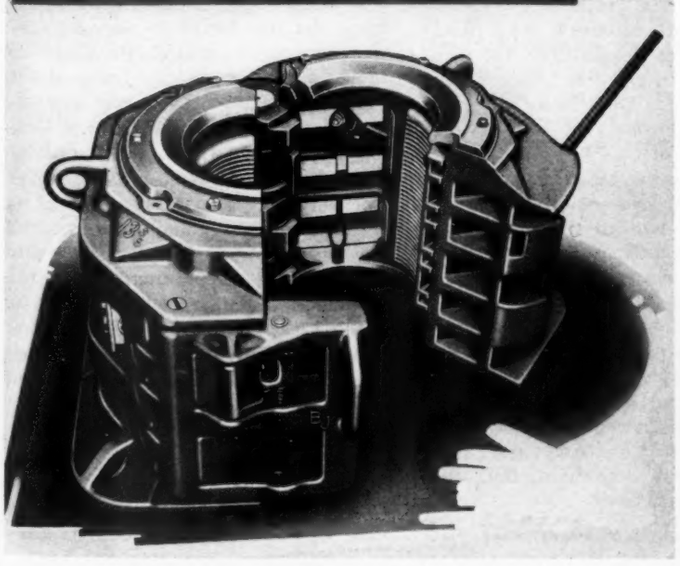

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per and Lower Cretaceous, the datum elevations of certain important horizons in the Meadows, Vaughn, and Brownfield wells are given in Table 9.

These datum elevations clearly indicate that general structural conditions in the lower formations may not correspond to the structure of the upper beds. For instance, it will be noted that the base of the Annona Chalk in the Meadows well is actually lower than in the Vaughn well, and that the same horizon is lower in the Vaughn well than it is in the Brownfield well. In contrast thereto the base of the "Massive" Anhydrite and the top of the Travis Peak are higher in the Meadows well than in the Vaughn well, and the same horizons are higher in the Vaughn well than in the Brownfield well. In complete reverse of this the top of the Cotton Valley formation in the Brownfield well is higher than it is in the Vaughn well, due, perhaps, in part to the transitional horizon encountered in the Vaughn well, although lower in the Cotton Valley formation the relative structural position may be again reversed inasmuch as the Vaughn well had only 160 ft. of black shales above the first sandy phase whereas the Brownfield had 307 ft. of black shales in the same approximate interval. Verily, much is yet to be learned regarding the subsurface structure of this region, and in consequence unusual care should be exercised in the selection of locations for additional test wells.

4. Description of producing formations and possible producing formations in the Lisbon-Sugar Creek area. There are four producing oil and/or gas horizons in the Lisbon-Sugar Creek area. These are, in descending geologic order: the Kilpatrick zone in the Sugar Creek field, the Pettit lime in the Lisbon field, the Darrett zone in the Sugar Creek field, and the Vaughn sand in the Lisbon field. These horizons along with other possible formations will be described in such detail as existing data will permit.

a. Kilpatrick zone. According to Clark[12], the Kilpatrick zone is a soft, porous, oölitic, gray limestone in which small cavities occur. It has an average thickness of 13 ft., ranging from 6 to 18 ft. Its porosity varies from 14 to 23 percent, averaging about 18 percent. It generally occurs immediately beneath the base of the "Massive" Anhydrite of the Glen Rose, although in some places a parting of from 2 to 6 ft. of dense, gray limestone or black shale separates the porous gas horizon from the anhydrite above. Although oil-stained cores have been obtained, no commercial oil production has been developed from this reservoir.

[12]Clark, C. C., previous citation, p. 1513.

TABLE 8

Abridged record of the Cotton Valley, Buckner(?), and Smackover(?) formations as encountered in the Brownfield No. 2 well, Sugar Creek field.

Unit	*Depth, ft.*	*Thickness, ft.*	*Description*
1	7787-8175	388	Black fossiliferous shale.
2	8175-8308	133	Hard, dense to slightly porous, gray to tan, fine-grained sandstone with partings of black shale.
3	8308-8410	102	Black shale with thin calcareous streaks.
4	8410-8425	15	Hard, gray, porous sand.
5	8425-8475	50	Black fossiliferous shale, gray sandy shale, fossiliferous limestones, and a few thin streaks of hard gray sand.
6	8475-8862	387	Hard, dense to fairly porous, gray calcareous sandstones, with minor streaks of black shale, gray sandy shale, hard fossiliferous limestones, and a few thin beds of conglomerate.
7	8862-9992	1130	Black shale with a few calcareous and fossiliferous streaks.
8	9992-10,000	8	Hard, dense, brownish-gray, fine-grained, shaley sand.
9	10,000-10,305	305	Black, calcareous shale with streaks of hard, black limestone.
10	10,305-10,415	110	Hard, gray, slightly porous, calcareous sands, and gray sandy shale. This possibly represents the Buckner formation.
11	10,415-10,759 TD	344	Black calcareous shale and hard dark gray and black crystalline limestone. These beds presumably belong to the Smackover formation.

TABLE 9

Important datum elevations in the Meadows, Vaughn, and Brownfield wells.

	Meadows No. 1 NE¼SE¼ *Sec. 13-21-S*	*Vaughn No. 1* NW¼NE¼ *Sec. 36-21-S*	*Brownfield No. 2* SW¼NW¼ *Sec. 5-19-S*
Surface elevation, ft.	256	364	234
Base of Annona Chalk	—2295*	—2270*	—2240*
Base of "Massive" Anhydrite	—3754	—3830*	—4088
Top of Travis Peak	—4896	—5030	—5246
Top of Cotton Valley	———	—7696**	—7553

*Estimated from subsurface structure maps.
**This figure is based on the supposition that Unit 8, Table 6 is a transitional horizon between the Travis Peak and Cotton Valley formations.

b. Pettit Lime. Grage and Warren[13] have given a very good description of the Pettit lime in their paper on the Lisbon field This is reproduced almost exactly with the exception that the lime is referred to as the Pettit rather than as the "Patton Producing Zone."

The top of the Pettit lime oil-producing horizon of the Lisbon field occurs at an average depth of 425 feet below the top of the Pine Island Member of the Lower Glen Rose, and at a depth ranging from 1055 to 1105 ft. below the base of the "Massive" Anhydrite, with the greater interval found in the southwestern part of the field.

The porous parts of the Pettit lime are made up primarily of oölitic and coquina-type limestones. These limestones are variable in composition as well as in porosity. The lithologic character of the porous limestones of the Pettit grades rapidly from fine-grained, sandy, cölitic, coquina-type limestones to dense cölitic limestones. These rapid changes in lithologic character are not limited to lateral variations, but also are marked vertically.

[13]Grage and Warren, previous citation, p. 304.

The thickness of the Pettit lime in the Lisbon field varies from 2½ to 20 ft., the average being around 12½ ft. The accumulation of oil, as previously stated, is controlled primarily by the lateral extent of porosity in the Pettit. In general the thinnest pay sections are found in the northern part of the field and the better pay sections, both from the standpoint of porosity and thickness, in the southwestern part of the field. The productive limits of the field are as yet not entirely defined. To the north the porous section thins down to a point where further drilling has not been justified, it being estimated that only one or two feet of porous, oil-bearing lime was encountered in the Meadows well. To the east and southeast the productive limits of the field are established by a change in the lithology of the Pettit from a porous bed to a hard, tight, shaley limestone. To the south and southwest there appear to be several locations that are as yet undrilled that probably are underlain by good pay sections. The unsatisfactory market for the crude oil has not encouraged extensive development of these untested locations dur-

ing the last year (1939). To the west and northwest the Pettit lime decreases in thickness, and also changes in lithology to a hard, dense bed.

The porosity of the Pettit lime in the productive area of the Lisbon field varies from 8 to 35 percent. The average porosity, based on all tests now available, is 19.5 percent. Oil saturation tests have ranged from 7 to 85 percent, the higher saturations being found in the tighter beds and the low saturations in the more porous and permeable beds. There are no definite gas pays present and in fact the amount of gas originally in solution in the oil appears to have been subnormal. The increase in gas-oil ratios since the discovery of the field is therefore more likely due to the decline in bottom-hole pressure, which permitted the undersaturated oil to give up its gas content readily when the critical solubility pressure was reached, than to the production of gas from any particular gas-bearing part or parts of the lime. This conclusion is verified by the fact that it has been observed that the control of gas production in wells that were completed by gun-perforation, where the perforations were largely restricted to the lower part of the pay, has been far more effective than in wells completed in the conventional manner. It is presumed that the gas coming out of solution, as the bottom-hole pressure has been lowered, may very likely move to the upper part of the porous zone and, if there controlled by selective perforation, a substantial volume may be held for some time to come.

The acidization of wells, although beneficial to initial production, may have had a tendency to cause dissipation of the formation gas by opening up the channels through which gas could move with greater freedom. Oil recovery, in relation to the decline in bottom-hole pressure, might have been improved greatly if the general acidization of wells had been deferred, and if casing had been cemented through the pay section and then perforated only in the lower part of the lime. Substantiation for the latter contention can be presented in the fact that wells completed by gun-perforation have continued to flow at a satisfactory rate for more than a year after offsetting wells completed in the conventional manner have been placed on the pump. The dissipation of reservoir energy by high production allowables during the early life of the field, by too-close well spacing, and by the poor utilization of the gas carried in solution in the oil, has not promoted the conservation of the oil resources or the effective production of oil in the Lisbon field.

The horizontal permeability of the Pettit lime, in such tests that have been made, has varied from 0 to 500 millidarcies. The higher permeabilities are not common, although zones of high permeability may occur in somewhat larger number than the tests indicate owing to the difficulty that has been experienced in the recovery of cores from the softest sections of the pay. The average permeability will probably not exceed 50 millidarcies, and this figure applies to the vertical permeability as well as to the horizontal permeability. There are large sections of the pay that have a permeability of not more than 25 millidarcies.

The low average permeability undoubtedly accounts for the difficulty that has been experienced in the maintenance of production from pumping wells. The oil content of the lime is probably quite high, but after the greater part of the original reservoir energy has been exhausted, the high resistance of the formation to fluid movement definitely retards the entry of the oil into the hole. Repressuring of the reservoir, therefore, appears to be the only effective method whereby a profitable recovery of oil can be realized.

c. Darrett zone. The Darrett zone is a far more important producing horizon in the Sugar Creek field than the Kilpatrick zone. It has been thoroughly described by Clark,[14] and his description is given here somewhat abridged.

In the Darrett zone, gas and oil occur in porous beds distributed throughout a thickness of 175 to 275 ft. This zone includes the transition beds between the Lower Glen Rose formation and the Travis Peak formation, having an average thickness of 55 to 65 ft. It also includes the upper part of the Travis Peak through an interval of 125 to 225 ft. The transition zone comprises a group of dense, gray, fossiliferous limestones, hard red and gray sandstones, and black and red shales. The upper part of the Travis Peak consists characteristically of red and gray sandstone interbedded with red shale and siltstone. The porosity within the zone is variable and the character of the wells drilled is dependent on the nature and total thickness of the porous beds encountered.

Oil is produced from two members of this zone along the lower flanks of the structure. Two wells have developed oil production from limestones and sandstones in the upper part of the zone on the west side of the field. One well has developed oil production from a sand lens near the base of the zone on the east side of the field.

d. Upper Travis Peak sands in the Vaughn well. It has been pointed out that the upper part of the Travis Peak formation in the Vaughn well carried a considerable number of sand bodies. No attempt was made to core these except for a section corresponding to part of the Darrett zone in the top part of the Travis Peak that was reported to have been oil-bearing in the Burgess well located in Section 3-20-5, and a sand and sandy shale section from 6925 to 6943 ft. that was believed to correlate with the lowest beds drilled in the Meadows well. The cores from these horizons showed no evidence of oil or gas content.

The recognition of the presence of the Upper Travis Peak sands in the Vaughn well is in part based upon the electrical log record. These sands are quite fine-grained, and are so loosely-cemented that little evidence of their existence can be detected from an examination of the drill cuttings. A mechanical sampling device was used for the collection of cuttings that provided very representative samples of the coarser fragments, such as resulted from the drilling of shales and hard sands. It would not, however, preserve the fine sand grains that were carried on through with the return mud flow stream.

A gas detector was installed on the return mud flow line before deepening operations were begun, and the record of this instrument combined with the electrical log has indicated several horizons in this part of the Travis Peak that may be gas-bearing. These, along with the record of other sands in this section, are listed in Table 10.

[14]Clark, C. C., previous citation, p. 1516.

TABLE 10

Record of possible gas-bearing sands, and water-bearing sands in the upper part of the Travis Peak formation as indicated by gas detector and electrical log, as encountered in the Roberta Vaughn No. 1 well.

Sand unit	*Formation record depth. ft.*	*Electrical log depth. ft.*	*Probable content*
1	5535-5546	5530-5540	Salt water
2	5625-5631	5620-5630	Gas
3	5665-5702	5660-5710	Salt water
4	5805-5865	5810-5868	Salt water
5	5977-5985	5975-5988	Little gas
6	No record	6095-6117	Salt water
7	6675-6690	6660-6698	Salt water
8	6710-6725*	.....	Gas

*This is a very broken section of tight sands and sandy shales.

The variation between the depths on the formation record and the electrical log depths may be attributed to the poor recovery of cuttings from the sands. Under such circumstances the electrical log depth records are far more reliable.

Sand No. 2 possibly is equivalent to one of the lower sands in the Darrett zone. It very likely would produce enough gas to make a small well. Sand No. 5, although probably gas-bearing, is likely too tight to produce in commercial quantities. The upper part of Sand No. 7 may carry some gas, although the probability is that this sand for the greater part is water-bearing. The broken sands and shales in Sand No. 8 gave a very strong indication on the gas detector, but their permeability is probably too low to permit any appreciable production.

None of these sands, in all probability, carries sufficient gas to justify the drilling or deepening of wells to them for gas production alone. Sand No. 2 apparently carries enough gas at the structural level of the Vaughn well to make it an interesting possibility for oil production farther down the dip. The distance between it and the Pettit lime is so small that it would not be a very difficult undertaking to deepen a well to it. Its thinness would not encourage the drilling of wells from the surface of the ground even should it prove to be oil productive in other parts of the field.

Insofar as the record of the Vaughn well can be depended upon, and excepting the possibility of developing some production from Sand No. 2, the oil and gas possibilities of the Travis Peak sands in the Lisbon field are not very promising. It should, however, be kept in mind that the distribution and lateral extent of the various beds of the Travis Peak are most erratic, and that sand lenses may be found in other parts of the field, particularly in lower structural areas, that might prove to be productive.

e. Lower Marine sands in the Lisbon field. Four separate and distinct Lower Marine sand bodies were encountered in the Cotton Valley formation during the course of drilling the Vaughn No. 1 well. These are represented as units 3, 6, 9, and 11 of the Cotton Valley formation in Table 7. The formation record and the electrical log of these sands are graphically shown in Fig. 1.

In general the presence of sands in the Cotton Valley formation can be rather easily detected owing to the fact that they usually drill much harder than the shales or lime streaks. In addition, by maintaining a constant record of the performance of the gas detector, the penetration of the bit into a gas-bearing formation can readily be established. For the lack of any better names, hereinafter Unit No. 3 will be referred to as the First Sand, Unit No. 6 as the Vaughn Sand, Unit No. 9 as the Second Sand, and Unit No. 11 as the Third Sand. A description of these sands from an examination of cores and drill cuttings is given in Table 11.

Editor's Note—The discussion of geology will be concluded in the next installment, followed by presentation of the details of drilling.

TABLE 11

Description of Lower Marine sands encountered in Roberta Vaughn No. 1, Lisbon field, Louisiana.

First Sand from 8351 to 8386 ft.

108.0 in.—Not cored. Cuttings showed hard, gray, tightly-cemented, fairly coarse-grained sand.
6.0 in.—Hard, brownish-gray sandstone.
12.0 in.—Hard, gray, crossbedded sandstone.
16.0 in.—Hard, brownish-gray sandstone.
4.0 in.—Hard, gray calcareous sandstone.
10.5 in.—Hard, brownish-gray sandstone.
9.0 in.—Hard, calcareous and fossiliferous sandstone.
4.0 in.—Hard, gray sandstone.
15.0 in.—Hard, brown sandstone.
3.0 in.—Hard, calcareous and fossiliferous sandstone.
17.0 in.—Hard, brown sandstone.
6.0 in.—Hard, gray, calcareous and fossiliferous sandstone.
19.0 in.—Hard, brownish-gray sandstone.
36.5 in.—Core lost.
11.0 in.—Hard, gray sandstone.
3.0 in.—Gray, shaley sand with an asphalt vein.
14.5 in.—Hard, gray sandstone.
25.0 in.—Hard, brownish-gray sandstone.
62.0 in.—Hard, shaley sandstone with stains of asphaltic residue.
14.5 in.—Very hard, dense, calcareous sandstone.
24.0 in.—Not cored. Cuttings showed hard, gray sandstone.

Remarks:
The gas detector gave no indication that the First Sand was gas-bearing, and the electrical log indicated that it carried salt water. Later production tests proved that this was the case, although there is possibly a very thin gas-bearing section at the very top of the sand. No distinct odor of oil or gas could be determined from the examination of fresh core fragments.

Vaughn Sand from 8452 to 8464 ft.

Remarks:
Unfortunately no cores were taken of the Vaughn sand, so that the only record available of its character is derived from an examination of drill cuttings, and from the electrical log. It was not cored because it is evidently much more porous and permeable than the other Lower Marine sands that were encountered, and as such it drilled, in time intervals, so much like shale that its presence was not detected until a strong show of gas was indicated by the gas detector. Inasmuch as there was a considerable lag in the return of mud from the bottom of the hole, it seems quite certain that about 10 ft. of sand were drilled before the existence of the Vaughn horizon was recognized. Further proof of the productive possibilities of the Vaughn sand, before the well was completed, was established when the well made a serious attempt to blow out after the second electrical survey was made. It required 13 hr. to condition the mud and kill the flow of light oil and gas coming from the Vaughn sand.
Fragments of the sand, collected from the return mud flow line, show it to be very soft, porous, coarse-grained, brown sandstone.

Second Sand from 8815 to 8843 ft.

27.0 in.—Not cored. Cuttings showed hard, calcareous sand, and some soft, calcareous, brownish-gray sand.
7.0 in.—Porous, brownish-gray sandstone.
7.0 in.—Hard, calcareous sandstone.
45.0 in.—Porous, fairly soft, brownish-gray sandstone.
10.0 in.—Hard, calcareous sandstone.
33.0 in.—Porous, fairly soft, brownish-gray sandstone.
9.5 in.—Very hard, calcareous and fossiliferous sandstone.
6.0 in.—Porous, fairly soft, brownish-gray sandstone.
23.5 in.—Medium hard to hard, calcareous sandstone.
2.5 in.—Porous, fairly soft, brownish-gray sandstone.
15.0 in.—Slightly calcareous, fairly hard, brownish-gray sandstone.
20.0 in.—Hard shaley sandstone.
47.5 in.—Porous, fairly soft, brownish-gray sandstone.
17.5 in.—Hard, calcareous, gray sandstone.
5.5 in.—Core lost.
9.5 in.—Fairly hard, brownish-gray sandstone.
28.0 in.—Fairly hard, gray sandstone with somewhat calcareous, thin shale laminations.
16.5 in.—Hard, somewhat calcareous, dark gray, shaley sandstone.
6.0 in.—Very hard, gray, calcareous sandstone.

Remarks:
Fresh core fragments from the Second Sand possessed a good odor of gas/distillate, and quite a few bubbles of gas could be seen breaking out from the cores when they were removed from the inner barrel. The gas detector gave a strong indication of gas in this sand.

Third Sand from 8852 to 8860 ft.

80.0 in.—Not cored. Cuttings showed coarse-grained, gray sand.
16.0 in.—Hard, slightly porous, gray sandstone.

Remarks:
Fresh fragments of core from the Third Sand carried a strong odor of gas/distillate. The gas detector indicated that it was gas-bearing.

TALK ABOUT A TIGHT JOB!

Photos above show Lisbon Exploration Company's Roberta Vaughn No. 1 in Lisbon Field, Claiborne Parish, Louisiana. Read interesting story on page 31, February 1st issue, *The Oil and Gas Journal*, and the series of articles now running in *The Petroleum Engineer* covering this well, by Paul D. Torrey and Frank H. Miller.

REG. U. S. PAT. OFF.

Clearances So Close That Couplings On The Casing Had To Be Machined!

BUT *Inferno* CAME THROUGH IN THE PINCH!

7-inch casing had been set at 5295 feet in an old well in the Lisbon Field. It was decided to make a deep test on the same location . . . the Roberta Vaughn No. 1 of the Lisbon Exploration Company, Inc. Here a 6¼-inch hole was drilled through to 8900 feet. 5-inch casing was run to 8884 feet. *Clearances were so close that couplings on the casing below 5295 feet had to be machined down from 5¾ inches to 5⅜ inches!*

This well was cemented with TRINITY *Inferno*. Slurry was pumped down, and the plug bumped in 25 minutes. Maximum pressure required was only 800 pounds above normal circulating pressure. Low water-cement ratio slurry. Bottom hole temperature, 208 degrees.

Mr. Paul D. Torrey, chief engineer on the job, was enthusiastic about the results and said, "We have every evidence that the cement set uniformly with a dense, hard sheath around the casing. Subsequent shooting showed no channeling and an even distribution."

It will pay you, too, to play safe on every job with TRINITY. Whatever your cement needs, Trinity Portland Cement Company—with years of proven experience and integrity—can supply you. Three conveniently located plants assure prompt delivery.

TRINITY PORTLAND CEMENT COMPANY

DALLAS • FORT WORTH • HOUSTON

There's a TRINITY CEMENT *for* EVERY CEMENTING NEED

Acid Treatment of Sand Well Revives Production

Well in Tomball field, Harris County, Texas, about to be abandoned, becomes steady producer when cleaned-out by chemical

By H. LEE FLOOD
Associate Editor

SINCE the first successful acid treatment of a Gulf Coast sand well in 1937, even since this type of work was described in this magazine last July[1], the use of acid in sand wells of the Gulf Coast has increased until, in many fields, the method has become an accepted practice by many operators.

Perhaps in no phase of the highly technical field of chemical treatment of oil wells is it so important to stress the importance of proper reagents and intelligent conduct of the treatment as in the treatment by acid of sand formations. This is emphasized by the fact that only because an effective surface-tension reducing agent is available, after intensive research to develop it for the specific purpose, it is possible to inject acid into sandstone and recover the spent acid and products of the reaction without clogging the interstices of the rock. The acid, of course, does not attack the silica in the sandstone itself but dissolves readily the carbonaceous cementing material usually present in most sandstones to some extent.

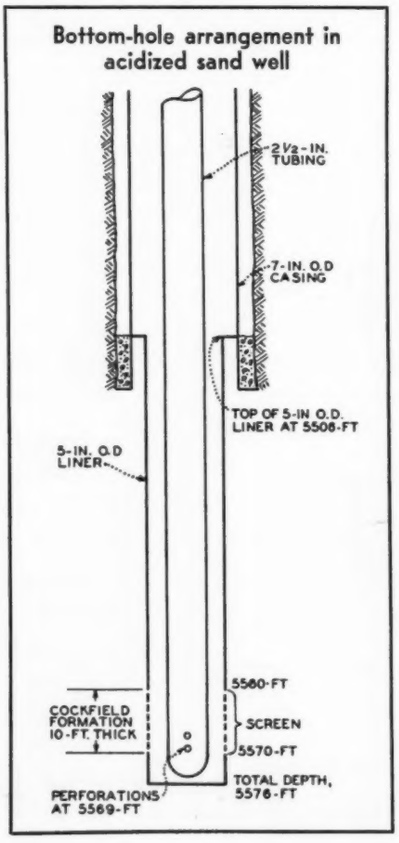
In many Gulf Coast fields, producing sands tend to become clogged by concentrations of carbonaceous material near the face of the formation. This same tendency often causes perforated screens to become clogged and, many times, so firmly cemented that it is impossible to remove the screen from the well for cleaning. The effectiveness of acid treatment as a means of cleaning screens and sand faces has been a welcomed solution of an aggravating production problem.

Although most of the treatments have involved remedial work in older wells, new wells also have been benefited by acid action on the cement, mud, and other materials in the well that may be acid soluble.

Of the many interesting treatments that have been made during recent months, the one selected for discussion here is an example of the beneficial results that often are obtained by the use of acid in sand wells.

The treatment to be described was made on a well in the Tomball field, Harris County, Texas. Completed in 1936, the well had an initial flowing production of approximately 550 bbl. of oil per day. During the drilling of the well, it had been necessary to plug-back and side-track but the well was finally completed at 5576 ft., the depth shown on the sketch as the present total depth of the well. Seven-in. casing was set and 70 ft. of 5-in. liner was installed having a 10-ft. screen section inserted from 5560-70 ft., opposite the Cockfield formation, described here as sand and broken shale.

Summarizing its production record briefly, the well produced at close to its initial potential capacity for a brief period and then began declining in oil production. Water began appearing gradually also until in July, 1939, the well stopped flowing entirely. Believing this to be caused only by a lack of sufficient energy in the formation, the well was equipped for gas lift by inserting a 1-in. string within the 2½-in. tubing string. An effort was made to induce flow by injecting gas for lifting purposes but it was found that not enough fluid was entering the hole to be lifted. After about a month of fruitless effort, it was decided to resort to acid as a possible means of saving the well from abandonment.



In the treatment used in the well, the Carr method was employed to pump-in 1000 gal. of chemical. This process involves first filling the tubing and annular space with oil and then displacing the oil in the tubing by the chemical by opening the casinghead and bleeding-off the oil displaced. This method also provides a "cushion" of oil in the annular space that prevents the chemical from entering the annular space during the "squeeze" of the acid into the formation. After the chemical is in place ready for introduction to the formation, the casinghead is closed and the chemical pumps are used to pump water into the tubing and thus "squeeze" the acid into the formation.

Beginning at a pressure of 500 lb. in the tubing, the pressure quickly increased to 1800 lb. The pumps were shutdown for 10 minutes to observe the rate of pressure decline and to permit the acid to begin its work. At the end of the brief period, the pressure had only decreased to 1500 lb., indicating that the formation was "tight" and not taking the acid readily. Resuming pumping, the pressure was increased slowly until 2200 lb. was reached. At this point, the acid broke through, permitting the formation to take the chemical much faster.

Following the treatment, the spent acid, water, and oil were removed from the hole and the well gauged, in the first 24-hr. test, 240 bbl. of oil and 75 bbl. of water, representing a tremendous increase in oil production and only a slight increase in water volume. Casing pressure of the well had been restored to 1500 lb. per sq. in.

This well has been watched during the few months since its successful treatment and, at the last report, is producing substantially the same volume just subsequent to treatment.

[1] "Acid Treatment of Sand Wells in Gulf Coast Fields," by H. Lee Flood, *The Petroleum Engineer*, July, 1939.

Internal-Combustion Engines Used in California Deep Drilling

Well at Wheeler Ridge, drilled to a depth of 11,168 ft., is deepest test ever drilled by internal-combusion engine—900 ft. of 12¼-in. hole in 6 hr. in an East Montebello field well is example of speed attained

By WALLACE A. SAWDON
Pacific Coast and Foreign Editor

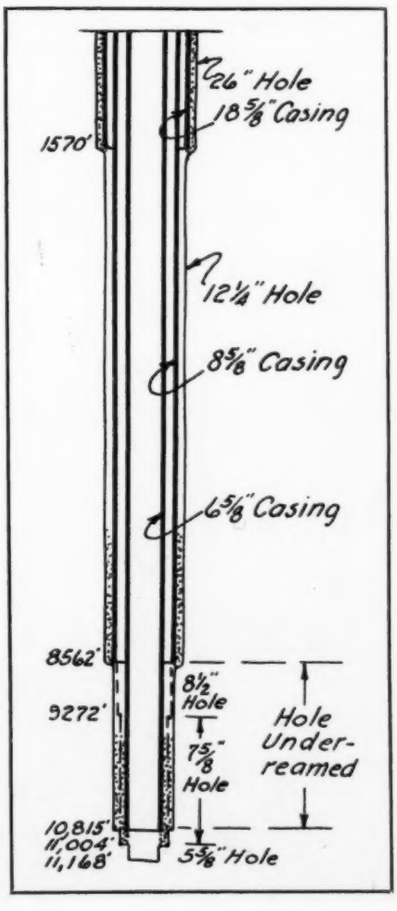
THE drilling of a well to below 11,000 ft. with a gas-engine-powered rig has demonstrated the adaptability of internal-combustion engines to meet the requirements of deep drilling when conditions make the selection of this type of equipment advantageous. Wells in California drilled recently with rigs powered by gas, butane, or Diesel engines have ranged in depth from 3,500 to 11,168 ft., the greatest number being completed at depths from 7,000 to 8,000 ft. This does not include portable hoists and drawworks that are widely used for repair work and even for drilling to depths frequently greater than 4000 ft. The drilling rigs here discussed, although unitized for portability like much of the surface equipment now used for rotary-drilling operations, are installed on the rig floor in a manner similar to that of other deep-drilling rigs. Engines of any desired horsepower, of course, are available for driving these rigs, but the design of the rig using the power is of prime importance to efficient drilling.

Perhaps the factor of greatest importance in selecting an internal-combustion-engine-powered rig is the availability of water or fuel, or both. There are places in California, sometimes not far from settled areas, where water suitable for use in boilers has to be purchased at high prices and transported at great inconvenience. At other locations the necessary supply of water is not available. Boiler trouble due to feedwater containing high calcium content or other deleterious substances is naturally avoided whenever possible and frequently can be overcome only by eliminating the boilers entirely. Under such conditions, and where natural gas is available for fuel, the gas engine can be used as a prime mover.

When natural gas is not available, gas engines in many instances are now converted to burn butane by the addition of heaters, no change in carburetors being necessary. Gasoline is seldom used for rotary drilling, as butane is a cheaper and more efficient fuel. Moreover, butane enters the carburetor as a gas and remains a gas; therefore it does not dilute the oil. The amount of liquid butane consumed per hp-hr. is approximately the same as the amount of gasoline but the cost per gal. is much less. Depending on the distance of the well from the point of distribution, butane in California costs from 5.5 to 6.0 cents per gal. within a haulage distance of 25 to 30 miles.

Cylinders supplied for the use of liquid butane usually have a capacity of 519 gal. or 330 gal. The larger type is 3 ft. in diameter by 11 ft. long and the smaller 3 ft. in diameter by 7 ft. 3 in. long. These cylinders are supplied by the gas company, and one of the larger size or two of the smaller sizes are generally left at the rig. These are recharged by tank trucks to about 90 percent capacity at an approximate pressure of 97 lb. at 100°F. The cylinders provide about a two-day supply for a medium-sized rig but have to be recharged every day on a large rig, as the larger engines consume approximately 500 gal. per day.

Fig. 1. Drilling and casing program of deep test in Wheeler Ridge field, California



Diesel engines have also been used to some extent when natural gas is not available and even at locations where steam could be used. On wells drilled by Diesel power to depths of approximately 8000 ft., two 225-hp. engines are used. These are 6-cylinder engines and in drilling wells to a depth of 8000 ft. will consume an average of about 6.5 bbl. of fuel oil per day.

Fuel consumption frequently is an important item that has governed the selection of internal-combustion engine rigs for certain jobs. The rigs of this type now in service in California are more or less standardized in design and are compact in construction, and afford substantial economies in transportation and in setting-up and tearing-down time. When the haul required is 20 to 30 miles the gas-engine or Diesel-driven rig can usually be moved to location and set-up in approximately 8 hours.

The Richfield Oil Corporation's deep test recently drilled at Wheeler Ridge, California, is the deepest well yet drilled with a rotary rig powered by an internal-combustion engine. The total depth was 11,168 ft. The hole sizes and casing program are shown in Fig. 1. The 18⅝-in. surface string was slip-joint casing run in 26-in. hole and landed at 1570 ft. The next string, 8⅝-in. casing, was set at 8562 ft. From that depth 8½-in. hole was drilled to 9272 ft., where the hole size was reduced to 7⅝-in. After reaching 11,004 ft. with 7⅝-in. hole it was decided to set a string of 6⅝-in. casing at 10,815 ft., so the hole was underreamed from the shoe of the 8⅝-in. casing at 8562 ft. to 10,815 ft., at which depth the 6⅝-in. string was cemented. From this depth a hole of 5⅝-in. diameter was drilled to bottom.

A string of 5-9/16-in., 22.2-lb. drill pipe was used to approximately 6000 ft., 4½-in., 16-lb. to 9000 ft., and 3½-in., 15.5-lb. to bottom. From 9272 ft. (where hole was reduced to 7½ in.) to 10,400 ft. approximately 25 percent of the hole was cored, drilling and coring of which was accomplished in 24 days. From 10,400 ft. to 11,004 ft. the hole was cored in 16 days. The hole was cored from 11,004 ft. and tested to its total depth after the 6⅝-in. casing had been cemented.

The rig used in drilling this well was powered by two 6-cylinder, 350-hp. gas engines equipped with dual ignition and carburetion. The engines were combined to drive the drawworks, rotary machine, and two pumps. Transmission of power to the pumps was through 14 V-belts to each pump, one pump being 7¾ in. by 20 in. and the other 7¼ in. by 14 in. The pumps were installed approximately 7 ft. lower than the rig floor, the V-belt drive being angled downward. The distance from the driveshaft to pumpshafts was about 10 ft. The load could be divided between the engines by clutches to give flexibility of operation.

The entire rig, including prime movers, was comprised of five units mounted on structural-steel skids to facilitate hauling, setting-up, and tearing-down. In the five units were the drawworks, transmission, two engines, and a master frame standardized to carry the other units without the necessity of lining-up and onto which the four other units were bolted.

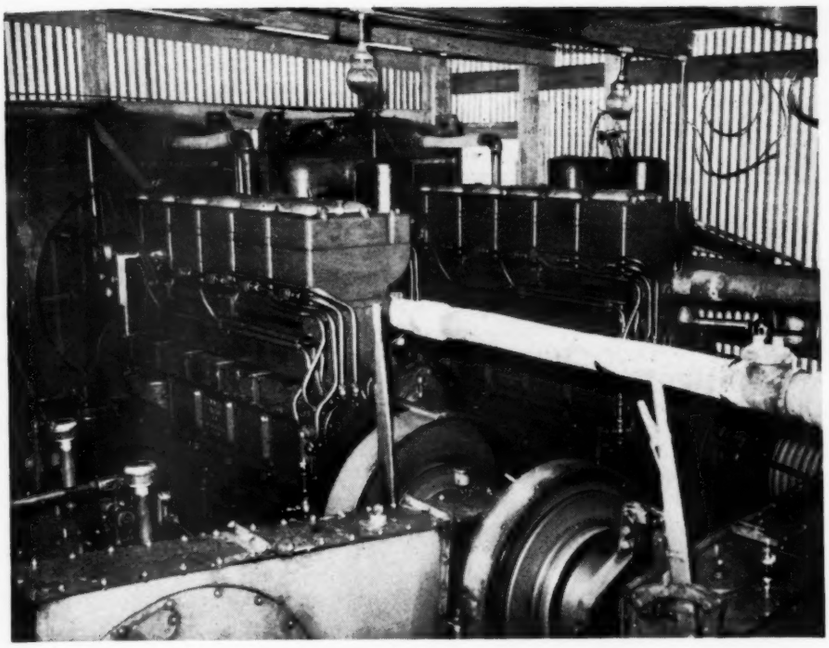
Power is transmitted to the drawworks through a chain-driven, oil-bath transmission the front of which is supported by the outpost shaft that rides on two spherical bearings in steel housings, a third point of support being a shock-absorbing rubber mounting.

Brakes are 10 in. wide by 54 in. in diameter and are effective over 90 percent of the total surface. One hydromatic brake was used on the left side of the drawworks. The cathead has automatic control and a vertical ball-bearing catline guard was used to protect the driller.

The average daily fuel consumption for nine full months of drilling was 34,000 cu. ft. The daily average during the minimum month was 22,000 cu. ft. and during the maximum month was 44,000 cu. ft. Partial operation during the month, usually on special jobs such as reaming, gave lower average daily consumption but did not reflect the actual consumption during drilling. The greatest fuel consumption was during the deepest drilling and coring before the 6⅝-in. casing was set and cemented. Actual daily consumption during the deepest drilling exceeded at times the average for the maximum month.

Speed, of course, is not such an important factor in a test well when geological information and knowledge of subsurface conditions is the primary consideration. The hole-making ability of a rig of the type described above is better illustrated by a well drilled by Kern Drilling Corporation in the East

Gas-engine-powered rig that drilled to a depth of 8040 ft. in Coalinga Extension, California



Drawworks, rotary table, and mud pumps are powered by these two Diesel engines

Montebello field, California. The prime movers used on this well were 2-V12 cylinder, 350-hp. gas engines and the size of the pumps 7¼ in. by 18 in., but the rig was the same size as the one described above. The well was drilled to a depth of 7640 ft. in 26 drilling days, this time including the cementing of the surface and water strings. After landing and cementing the 13⅝-in. surface casing in 18-in. hole at approximately 700 ft., 900 ft. of 12¼-in. hole was made in six hours.

A similar installation but one having a new model drawworks is now drilling north of Tulare Lake in the San Joaquin Valley, California. This well is scheduled to go to 11,000 or 14,000 ft. Another rig of the same type has spudded-in on a wildcat test just south of the city of Los Angeles.

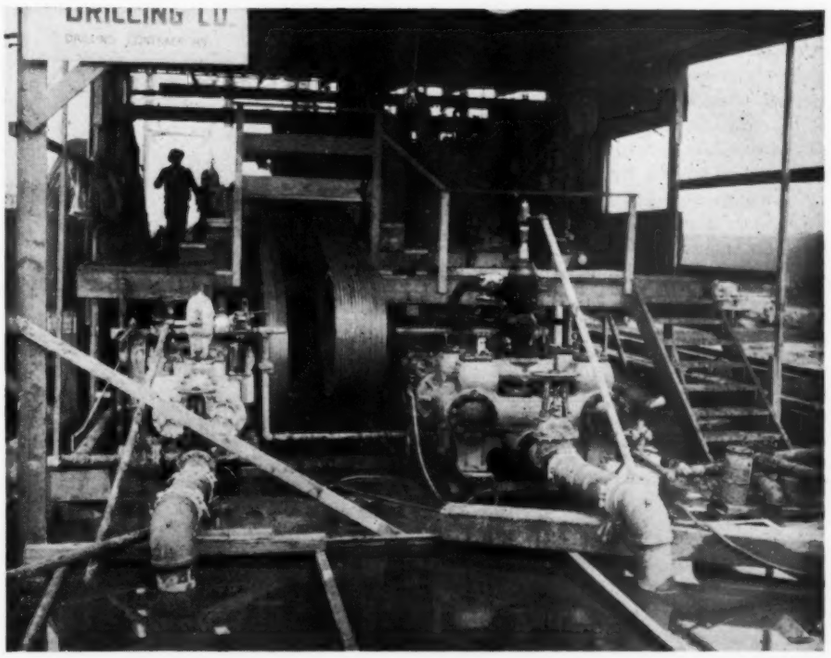
This new drawworks has six speeds forward and two reverse. Air-operated clutches and air control of operation affords flexibility approximating that of steam equipment. Air reservoirs are built-in as part of the frame and air is supplied by a compressor for a 125-lb. air system. The drum is constructed of 56½-in. diameter flanges and the spooling space between flanges is 48 in. Spooling capacity with 1⅛-in. line is 5350 ft. A feature of the rig is the type of friction clutches used for the drum; these are internal-expanding, self-energizing, air-operated, and water-cooled. The water circulation is in through the shaft and into a chamber between the internal-expanding clutch and the braking surface. The cold- and the hot-water streams in and out are separated by an insulated sheet that forms a split hole. A similar friction clutch is also used to throw the rotary table in and out of operation.

At Coalinga Extension where water can be purchased, but is hard and alkaline and not suitable for use in boilers, distilled water was used in the cooling systems of the gas engines, the ordinary water available being used only in the cooling system for friction clutches and brakes. This well was drilled to 8640 ft. by the new type rig. A string of 13⅜-in. surface casing was cemented at approximately 700 ft. and then 12¼-in. hole was drilled to 5000 ft. Hole thereafter was tapered at intervals until it was reduced to 11-in. in diameter at the total depth drilled. Fuel consumption on this operation averaged 55,000 cu. ft. of gas per day.

A smaller rig used to drill a well at Rio Vista was powered by two 225-hp. Diesel engines. This rig was adapted to the conditions encountered because the area is peat bog land and boiler foundations are difficult to make. The rig was placed on machinery supports that rested on timbers riding on peat bog. It was almost impossible to anchor-down and other types of equipment tended to work around and get out of line. Average fuel consumption on this well, which was drilled to a total depth of 4200 ft., was 6½ bbl. per day.

Another rig of the larger size was used to drill a well in the Huasna field near Santa Maria, the prime movers being two 350-hp. engines operating on butane. This well was first drilled to 3361 ft. with a lighter outfit and deepened to 5579 ft. with the larger rig.

In addition to wells drilled in the fields cited above, wells have been drilled with internal-combustion-engine power in California at Ventura Avenue, Santa Maria, El Segundo, East Coyote, Torrance, Long Beach Harbor, Harbor City, Wilmington, and Livermore.



A deep test being drilled with two 350-hp. V-12 gas engines. The larger mud pump is driven by 14 V-belts and the smaller by 6. A still larger pump than the former, also driven by 14 V-belts, can be substituted if desired

LAUGH WITH BARNEY

Sheer stockings—designed for dressy wear, but so serviceable that lots of women wear nothing else.—Advertisement in N. Y. paper.

* * *

Diner: I'll have pork chops with fried potatoes, and I'll have the chops lean.

Waiter: Yes, sir, which way, sir?

* * *

"We can't have any fun this evening. All I have in my pocket is some small change."

"Well, what do you think it takes to send my kid brother to the movies? A five-dollar bill?"

* * *

"Oh, doctor," said the young lady, "will the scar show?"

"That, madam," said the doctor, "is entirely up to you."

* * *

Husband: And now that we're married, I'll never leave you alone for a single night.

Wifey: Why, you suspicious lug.

* * *

The beautiful young girl shook her head decidedly. "No, Mr. Gotrox, I cannot marry you," she said. "You are over seventy and I am only sixteen."

The old man shrugged his shoulders. "All right, sweet," he sighed, "I'll wait."

* * *

Two young Irishmen in a Canadian regiment were going into the trenches for the first time, and their captain promised a dollar for every one of the enemy they killed.

Pat lay down to rest while Mike watched. Pat had not lain long when he was awakened by Mike shouting:

"They're coming; they're coming."

"Who's coming?" shouts Pat.

"The enemy," replies Mike.

"How many?" shouts Pat.

"About fifty thousand," says Mike.

"Begorra," shouts Pat, jumping up and grabbing his rifle, "our fortune's made."

* * *

I wish I were beneath a tree
A-sleeping in the shade,
With all the bills I've got to pay
Paid.

* * *

Title of this month's ditty: "She Was Only the Innkeeper's Daughter But They Couldn't Keep Her In the Inn."

Freshman (preparing an essay): What do they call those tablets the Gauls used to write on?

Roommate: Gaul stones.

* * *

Helen: Nobody can say anything bad about Mary.

Louise: That's so. Let's talk about someone else.

* * *

"Gee, married five years, and no children. Say, how do you avoid the stork?"

"We live in a trailer."

* * *

Co-ed's Lament

Here I sit and fuss and fret,
While my seat is getting wet,
It's enough to make me fume,
Teacher, can't I leave the room?
Why delay me when you know
That I simply have to go,
Honest, teacher, I'm not feigning,
My car top's down and it's raining.

* * *

Embarrassing

A young widow was entertaining some friends at a bridge party and was greatly embarrassed when the bell rang and her six-year-old son answered the door, calling out: "Maw, the insurance man is here again. Do you want to pay him or shall I go out to play?"

* * *

The top sergeant sang out just before the company was dismissed: "All those fond of music step two paces forward."

With visions of a soft job in the regimental band, half a dozen men stepped out.

The sergeant growled: "Now then, you six mugs get busy and carry that piano up to the top floor of the officer's quarters."

* * *

A fourflusher knows all the best people in town. The trouble is, they don't know him.

* * *

A Scotchman visiting a London friend overstayed his welcome. As Christmas was approaching, the host thought a subtle hint might get the desired result.

"Sandy," he asked, "don't you think your wife and family will want you with them at Christmas?"

"Mon," replied the Aberdonian, "I believe you're richt. It's thochtf' o' you. I'll send for 'em richt now."

—*The Lufkin Line.*

The Whiffle bird was perched high on a jutting rock in his mountain retreat gazing dreamily over the beautiful green valley that spread out below him. Suddenly he sighed, spread his wings and flapped lazily down, down in a graceful arc, skimming tree tops and rocks and as the verdant valley rushed up to meet him, swung dizzily on one wing, dipped lightly and flew back to his perch on the jutting rock. Heaving a sigh of contentment, he folded his wings and settled back.

To you that sounds like a lot of foolishness but to the Whiffle bird it's a hell of a lot of fun.

* * *

It happened in one of the "Help Yourself" joints where the honor system is supposed to prevail, but where they have spotters to watch you. You eat what you want and tell the cashier "how much." Our hero walked up to the receiver of the filthy lucre. "Two bits," he said. Just then he felt a tap on his shoulder. "How much?" said the cashier. "One buck," said our hero, and then turned around. "Gotta match?" said the fellow behind him.

* * *

A sweet little woman, meek of face and wearing gold rimmed spectacles, was applying for a driver's license.

"How many miles have you driven?" asked the official.

"Fifty thousand miles—and never had hold of the wheel," interposed her husband, stepping up.

She got the license.

* * *

Rastus was worried about a floating kidney his doctor had just told him he possessed. He therefore called on his pastor.

"Pahson," said he, "Ah done got a floating kidney and Ah want you to pray for me nex' Sunday."

"How come prayers for a floatin' kidney?" inquired Parson Jones. "De congregation would bust out laughin'!"

"Ah don' see why," insisted Rastus. "Last Sunday you done prayed foh all de loose livers!"

* * *

Hubby: Dear, you can't go to the theatre in your old coat, can you?

Wife (hopefully): Certainly not, darling."

Hubby: That's what I thought, so I only bought one ticket.

Running Tour
WITH MEN IN THE INDUSTRY

JAMES HUFFENDICK, petroleum engineer, Colombian Petroleum Company, Cucuta, Colombia, is spending his vacation in the United States.

GEORGE C. McGHEE, formerly vice-president of the National Geophysical Company, has become a member of the firm of E. DeGolyer and Lewis W. MacNaughton, Dallas, Texas. The firm is now known as DeGolyer, MacNaughton and McGhee and the scope of its activities has been enlarged, services now performed including property appraisals and consultation on problems of petroleum engineering, geophysics, and petroleum geology.

WAYNE COFFMAN, engineer at Russell, Kansas, for the Cities Service Oil Company, has been transferred to Bartlesville, Oklahoma.

M. W. SEAY, field superintendent at Cucuta, Colombia, for the Colombian Petroleum Company, is in the United States on vacation.

FRED E. HAKER, who joined the firm as a stenographer in 1900, has been made general manager of purchases of the Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin. He had been assistant manager of purchases since 1916.

T. P. HOFFER, formerly vice-president of the D. D. Oil Company, Mission, Texas, is now operating as an independent in the lower Rio Grande Valley area, principally in Starr and Hidalgo counties, Texas.

W. H. ROUZER, JR., who has been an engineer at Odessa, Texas, for the Phillips Petroleum Company, has assumed the position of chief engineer for the K.M.A. Pressure-Maintenance Association, which has headquarters in Wichita Falls, Texas.

EMIL MONSOUR has been made district geologist by the Sun Oil Company for its operations in Florida. He is stationed at Tallahassee.

E. S. BLEECKER, chief geologist, Gulf Oil Corporation, New York producing division, sailed recently for Venezuela.

WALDO SHELDON, manager of the Socony-Vacuum Oil Company, Inc., Caracas, Venezuela, who has been in the United States for some time, returned to South America recently.

FRANK I. BRINEGAR, vice-president of the Continental Supply Company, Dallas, Texas, has been elected president of the Dallas Petroleum Club. Other officers elected at a recent meeting are: **WILLIAM D. McBEE,** M. J. Delaney, Inc., vice-president, and **ELMER F. SCHMIDT,** vice-president and general manager of the Lone Star Gas Company, secretary-treasurer. New directors are: **JOHN G. PEW,** Sun Oil Company; **BRUCE C. CLARDY,** Heyser-Heard and Clardy; **CHARLES D. TURNER,** attorney, and **FRANK I. BRINEGAR.**

HENRY J. McADAMS

HENRY J. McADAMS has become associated with the sales staff of the New York district sales office of the Jones and Laughlin Steel Corporation, to specialize in the sale of oil-country tubular goods. He has been New York manager of the Tokheim Oil Tank and Pump Company since 1934.

LYNN K. LEE has been appointed chief geologist for the Texas division of The Pure Oil Company and will make his headquarters at Fort Worth. He has been division geologist at Olney, Texas. He succeeeds **FRANK PAULSEN,** who resigned to become a consultant.

J. H. RANKIN, divison engineer at Midland, Texas, for the Sinclair Prairie Oil Company, has been transferred to Great Bend, Kansas. He is succeeded at Midland by **J. V. KENNEDY.**

O. E. RITTER and **W. F. BLACKBURN,** engineers for the Oklahoma Pipe Line Company, have been transferred from Harden City, Oklahoma, to Graham, Oklahoma.

CHARLES TARR, engineer, Continental Oil Company, who has been at Oildale, California, is now stationed at Wasco, California.

H. C. W. JOHNSTON, director, and **VINCENT ILLING,** vice-president, Trinidad Leaseholds, Ltd., sailed from New York recently for Curacao, Netherlands West Indies.

F. M. DARNELL, engineer, Stanolind Pipe Line Company, is now stationed at Kansas City, Missouri. He has been at Bushton, Kansas.

CHESTER M. CREBBS, president of the Mene Grande Oil Company, recently returned to his headquarters at Caracas, Venezuela. He had been in the United States about a month on business and pleasure.

ROY SHEPPARD, superintendent in West Texas for the Noble Drilling Company, having his headquarters at Odessa, has resigned to become field superintendent for P. W. Appleby, Odessa, an oil-well clean-out service company.

W. W. WILLIAMS, general manager of The Babcock and Wilcox Tube Company, Beaver Falls, Pennsylvania, is relinquishing his position as of March 1 to go into business for himself on the Pacific Coast. Williams became associated with the B&W organization in 1929 as sales counselor and became in turn general sales manager and general manager of the company. The eastern climate greatly aggravated a bronchial condition that finally became so pronounced as to necessitate his moving to the Pacific Coast. He will shortly announce details of his new business venture.

STANLEY GAYNOR, engineer, Stanolind Oil and Gas Company, has been transferred from Odessa, Texas, to Iraan, Texas.

JOHN O'KEEFE, engineer for the Richfield Oil Corporation, has been transferred from Fellows to Taft, California.

E. L. BIRMINGHAM, engineer for the Margay Oil Corporation, has been sent from Houston, Texas, to Jackson, Mississippi, by his company.

W. H. MADDOX, geologist, Standard Oil Company of California, has returned to the United States from New Guinea where he has been on a company assignment.

O. B. HOPKINS, chief geologist for the International Petroleum Company, Toronto, Canada, is now in South America on company business.

CLAY TYLER, superintendent, Phillips Petroleum Company, has been transferred from Princeton, Indiana, to Hays, Kansas.

COSE VAN ERKELSENS, geophysicist in Papua and Sarawak, Borneo, for Bataafsche Petroleum Maatschappij, is in the United States, his first visit to this country.

EUGENE W. GILL, engineer, Phillips Petroleum Company, has been moved from Okmulgee to Duncan, Oklahoma.

L. W. KONZ, engineer for the Carter Oil Company, has been transferred from Mount Vernon, Indiana, to Harrisburg, Illinois.

J. W. HALE, assistant general superintendent of the telephone and telegraph department, Magnolia Pipe Line Company, Dallas, Texas, has been placed in charge of communications. **ANDY J. BALCOM,** general superintendent of the department, who is eligible for retirement this year, will continue to supervise activities pertaining to electric power.

E. E. MERKT, production foreman for The Texas Company in the Nocona, Texas, area, has been transferred to Wichita Falls, where he is assistant to **M. J. McGUIGAN** district superintendent.

M. C. PECK, chief clerk in the North Texas area for The Texas Company, has been transferred from Wichita Falls to Parks. He becomes chief clerk for the West Central Texas district. **NEAL W. GAUT,** formerly at Pampa, succeeds Peck at Wichita Falls.

WILLIAM K. BORLAND has resigned from the Olean Petroleum Company to accept a position with the A. C. Simmons Laboratory, Bradford, Pennsylvania.

F. L. LIVELY, production superintendent for the Humble Oil and Refining Company, has been transferred from Genoa, Texas, to North Crowley, Louisiana.

HAROLD F. GRAY, foreign representative for the Reed Roller Bit Company, has returned to his London office after having been away since April visiting oilfields in Sumatra, Borneo, and various other places.

A. A. DILL is in charge of export offices recently established by Jensen Brothers Manufacturing Company at 1850 Hudson Terminal Building, 50 Church Street, New York City. The cable address is "Axelson." Dill will be in charge of sales of Jensen pumping units and rod-line jacks in foreign fields.

R. A. LUDLOW has resigned as manager of the lubrication department of the Richfield Oil Company to become director of the recent inaugurated program of the petroleum industry toward a closer coöperation of that industry and the engineering and service departments of the automotive industry, according to an announcement by **W. H. CORREA** chairman of the lubrication committee of the American Petroleum Institute. This organization has already approved the plans of the lubrication committee for carrying out such a program.

A. C. AUSTIN, of the Seismograph Service Corporation, has been transferred from Chandler, Oklahoma, to Shawnee, Oklahoma.

G. F. POE, superintendent, Ohio Oil Company, who has been stationed at Lovell, Wyoming, is now making his headquarters at Casper, Wyoming.

W. H. CROUCH, who has been chief chemist at the Egyptian Government's refinery at Suez since 1925, has returned to London, England, where he expects to remain permanently.

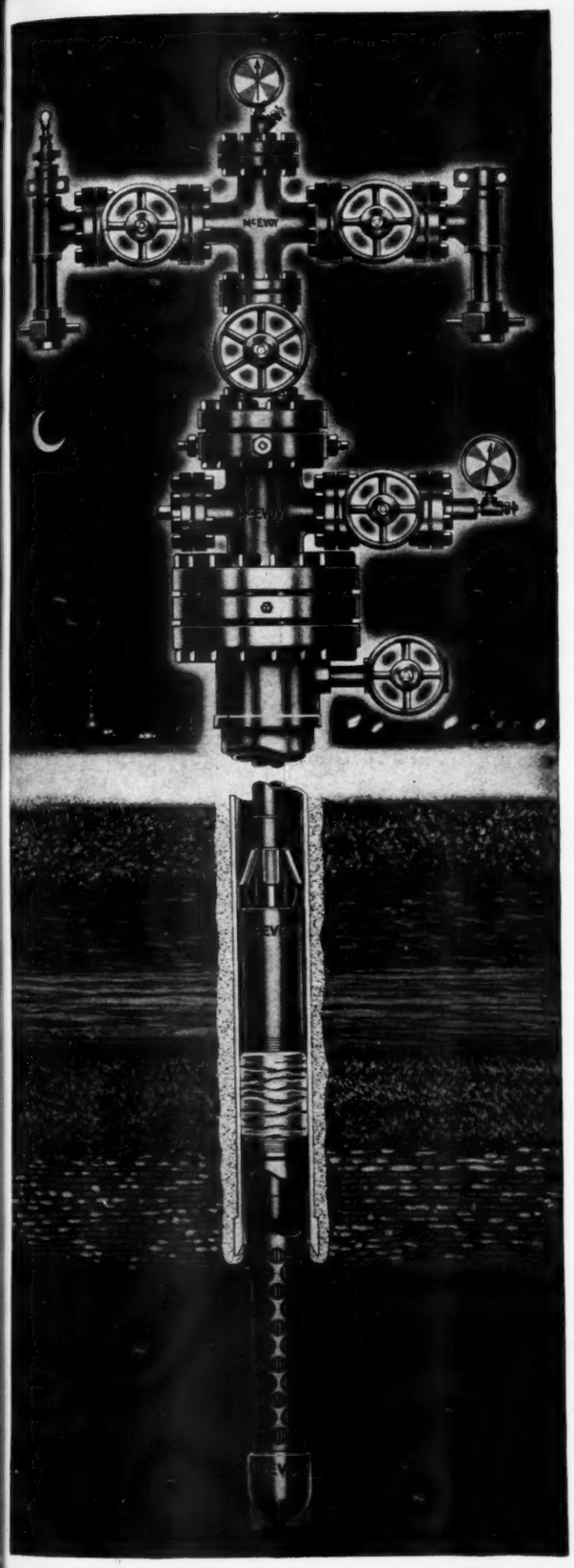
H. P. BINDER has been appointed assistant manager of the Centrifugal Pump Division of the Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin, it has been announced by **DR. WILLIAM M. WHITE,** manager and chief engineer of the company's Hydraulic Engineering Department. Binder, a graduate of the School of Electrical Engineering of Purdue University, was selected to enter the Allis-Chalmers Graduate Training Course in 1911. In 1912 he entered the Hydraulic Engineering Department where he served until 1917, at which time he joined the 9th Field Artillery of the regular army. At the conclusion of the war he returned to the Allis-Chalmers company. In the company's Centrifugal Pump Division he took up sales-engineering work, which necessitated visiting the various Allis-Chalmers district offices to assist salesmen on local problems. This work he continued until his appointment to the new executive post.

NOEL ROBINSON has resigned as vice-president and director of the Tide Water Associated Oil Company to accept a position as vice-president and director of the South Penn Oil Company at Pittsburgh, Pennsylvania. Robinson has a service record of 23 years with Tide Water Associated Oil Company. Succeeding him as a director of the Tide Water Associated Oil Company is **GEORGE J. HANKS,** who is vice-president in charge of transportation of the eastern division of the company, and was recently appointed vice-chairman of the operating committee of that division. He has been with the company and its subsidiaries for 25 years.

H. W. STRALEY, III, of the department of geology of Baylor University, Waco, Texas, and a group of advanced students, recently spent a week end studying the geology of the Arbuckle Mountains in the vicinity of Ardmore, Oklahoma.

J. HERELD COMAN has been appointed purchasing agent of W. C. Norris, Manufacturer, Inc., Tulsa, Oklahoma, to succeed **E. A. TAGGART,** who has been transferred to the sales department of the company.

New up-to-the-minute...



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ELIMINATES CONFUSION AT THE WELL AT A CRUCIAL TIME by CONCENTRATING RESPONSIBLITY IN ONE ORGANIZATION

★ **NO DELAYS DUE TO NON-FITTING PARTS.**

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by getting

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●

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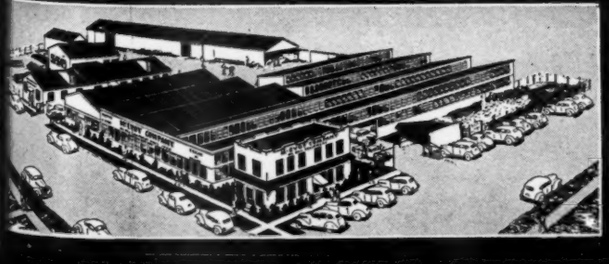

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MACHINERY and EQUIPMENT

Service Unit For Application of Rectorkote

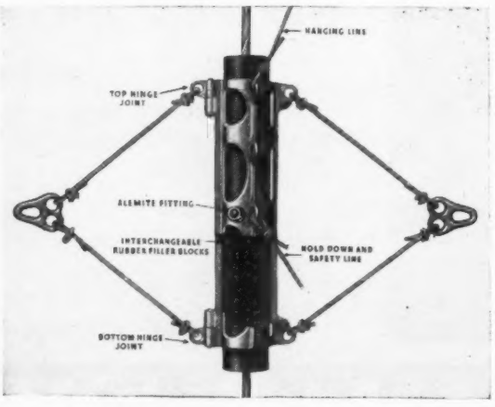
RECTOR Well Equipment Co., Inc., Fort Worth, Texas, has put into operation its first service unit for application of Rectorkote, a material for combatting corrosion of tanks caused by "sour" crudes and gasolines and salt water, and which has also found wide application as a coating for the inside of tubing and line pipe to prevent the accumulation of paraffin deposits. Some special equipment is necessary to obtain the best results, especially in tubing work, and this new service unit will make the advantages of Rectorkote available in localities where proper facilities are not available.

The unit, as shown herewith, consists of a gas-engine-driven compressor, capable of supplying 60 cu. ft. of air per minute at 100-lb. pressure. This volume of air is sufficient to supply two of the special oversize spray guns used in the work, as well as the air-line gas masks used by the operators when coating the inside of tanks, and also the air used in blowing-out tubing during the cleaning operation. A 1-kw gas-engine-driven generator, mounted alongside the compressor, supplies the necessary lights, and also powers the special motor-driven brushes used to clean the inside of tubing and line pipe.

With this unit, the coating work, whether on tanks or tubing, can be done in minimum time, and at low cost, with the assurance that failure will not result from misapplication, according to the company. The unit will be in charge of M. T. Harrell, formerly in charge of physical testing at the Houston, Texas, plant, to which office all inquiries for service work should be addressed.

Improved Wire-Line Guide

TO EXPEDITE the replacement of rubber sleeves when the latter finally become too worn for efficient service, Patterson-Ballagh has developed a hinged type, 4-section wire-line guide. The halves of the metal housing are held together by top and bottom hinge joints and clamped by lock nuts on the opposite side for quick removal of the rubber cylinder. This improvement is available only in the 4-section Patterson-Ballagh Wire-Line Guide, the manufacturer asserts. Hanging and hold-down lines are provided to stabilize the guide. Further details may be obtained from Patterson-Ballagh Corporation, 1900 East 65th Street, Los Angeles, California.



Hughes Tool Company Announces Major Development

THE introduction of the Hughes Unitized Drill Stem to the drilling industry marks the successful culmination of more than three years of intensive development, according to Gordon Richmond, general sales manager of the Hughes Tool Company, Houston, Texas.

"The advent of deeper drilling emphasized the necessity for an improved connection between tool joint and drill pipe—one that would develop the maximum strength of both. In developing the 'flash-weld' method of attaching tool joints to drill pipe, the Hughes Tool Company has entirely eliminated pipe threads, which, heretofore, have been the 'weak point' of the drill stem; of equal importance, this 'unitizing' has been accomplished without compromising in the physical properties that are best suited repectively for tool joint and drill pipe.

"Pipe of this construction is available from the various pipe mills, most of whom carry stocks at the Hughes Tool Company plant for immediate delivery."

Prices and complete information on Hughes Unitized Drill Stem are shown in the 1940 catalog of the Hughes Tool Company, which is now being distributed to the oil industry.

Crude-Oil-Burning Fuel System for Caterpillar Diesel Engines

A SPECIAL crude-oil-burning fuel system has been developed by Caterpillar Tractor Company and is now available for all 5¾-in. and 5¼-in. "Caterpillar" Diesel engines.

In the new "Caterpillar" system, crude oil passes from settling tanks through a heat exchanger to the fuel transfer pump on the engine. From the pump, it goes through a gross filter to the standard engine fine filter. From there it passes through the fuel-injection pumps into the fuel-injection valves, and into the cylinders of the engine.

Settling tanks are recommended for use with the system to lessen the amount of filtering required by the gross filter. When using these tanks, the fuel should be allowed to settle for at least 48 hours, and two or more tanks should be used, each of sufficient capacity to supply fuel for at least 48 hours of operation.

The gross filter removes most of the remaining dirt and abrasives from the oil. It consists of two compartments approximately 18 in. high by 8 in. in diameter, mounted on a base that also acts as a manifold for the oil. Each compartment contains two large filter elements, which can be easily replaced when necessary. A pressure gauge on the outlet side of the filters indicates when this should be done. A gauge is also used on the inlet side of the filters to indicate whether or not there is sufficient pressure on the fuel. A valve permits using only one compartment or both together, as desired, and the elements in either compartment may be changed without shutting down the engine.

The crude-oil injection equipment is the same in design as the standard "Caterpillar" Diesel fuel system; however, it is made of corrosion-resistant steel and has certain differences making it applicable to crude oil use. Like the standard Diesel fuel system, it has no operating adjustment. It provides satisfactory combustion throughout the entire speed and horsepower range of the engine, the makers assert. Performance is equally satisfactory, and is such that the regular Diesel fuel power curves apply to the crude-oil-burning engines, it is stated.

"CLEVELANDS"

DELIVER MATCHLESS PERFORMANCE Because of MATCHLESS SPECIFICATIONS . . . . *Dig Anywhere . . . Anytime . . . with them and*

WATCH YOUR COSTS GO DOWN

On transmission and main lines—scattered field and gathering lines—"hot spot" reconditioning or taking up existing lines—stripping pipe—wherever you put them—Clevelands, field-tested in all soils and topography, are delivering maximum footage day in and day out, on every job.

And there's a reason—Correctness of Design plus unexcelled Quality of Construction. Compact, fast, flexible and mobile, they are easy to operate. Rugged and amply powered for the toughest task, they show savings you never thought possible. Get specifications and details today.

THE CLEVELAND TRENCHER COMPANY

20100 St. Clair Avenue *"Pioneer of the Small Trencher"* **Cleveland, Ohio**

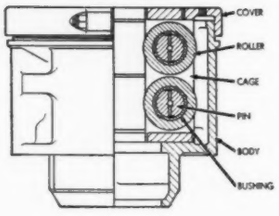
Another important reason why Clevelands save more is because of the low cost transportation at truck speed, via special trailer—"Clevelands" load or unload in 10 to 15 minutes.

CLEVELANDS

Baash-Ross Type 2RS Roller Kelly Drive Bushing

A FUNDAMENTALLY improved, heavy-duty, roller kelly drive bushing, designated the 2RS Roller Kelly Drive Bushing, is now available from the Baash-Ross Tool Company. This newly developed roller kelly drive bushing features unusually heavy construction throughout, and has been designed especially for the heavy torque loads and high rotation speeds of modern deep-well drilling, the manufacturer states. Each of the driving surfaces of the kelly is contacted by two extra-large diameter rollers and by no other part of the drive bushing. These rollers provide adequate contact area with the driving surfaces of the kelly, reduce frictional resistance to feeding, and prevent tearing or corrugating the kelly faces.

Torque loads are transmitted directly through each of the highly hardened driving rollers to a replaceable inner



roller bushing that absorbs virtually all wear. The roller bushings in turn ride upon large-diameter reversible roller pins that are case-hardened and ground to minimize wear. When one side of the roller pins becomes worn, the pins can be reversed so that virtually double pin life is assured, it is pointed out.

The advantage of this type of drive bushing, according to the manufacturer, is that the roller action causes the kelly to feed through the rotary easily, allowing a more sensitive feed control, more accurate weight indications, and freedom from binding. Also, the inner bushings and reversible roller pins provided in the design confine wear to the least expensive parts of the roller kelly drive bushing.

Further information about the Baash-Ross Type 2RS Roller Kelly Drive Bushing is now available in bulletin form from the Baash-Ross Tool Company, 5512 Boyle Avenue, Los Angeles, California.

Link-Belt Vernier-Control Variable-Speed Transmission Announced

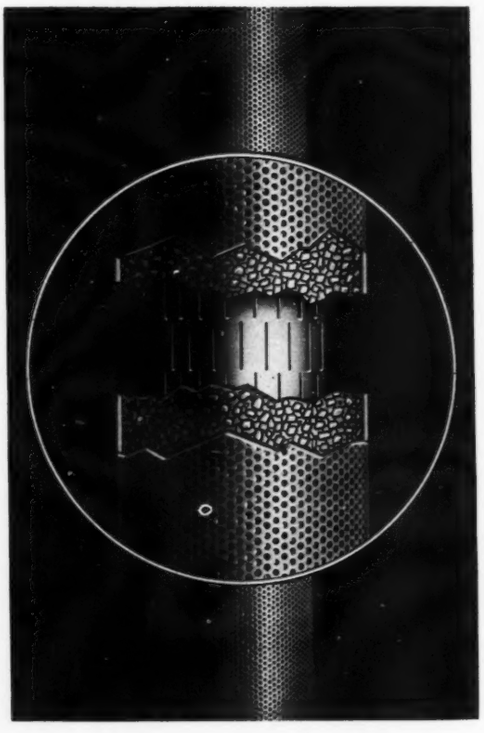
ANNOUNCEMENT is made by Link-Belt Company, Philadelphia, Pennsylvania, that it is now in position to equip all sizes of the Link-Belt P.I.V. Gear variable-speed transmission with vernier control, for installations where extremely fine control of speed changes is required.

This vernier control can be supplied with either one of two ratios—7½ to 1 or 30 to 1, and is equipped with two handwheels. One is for direct control; the secondary, or vernier type control handwheel, will provide either 30 turns or 7½ turns to one of the direct wheel, depending upon which ratio of worm-gear reduction set is supplied.

Link-Belt Company's 40-page booklet No. 1574 covering vernier and other types of P.I.V. Gear control, will be sent to any reader upon request addressed to the company at 2045 West Hunting Park Avenue, Philadelphia.

Pacific Perforating Company's Gravel-Packed Liner

FOR controlling entrance of sand into the oil string, Pacific Perforating Company, Torrance, California, has introduced a pre-packed gravel liner that the manufacturer states incorporates many new construction and engineering features.



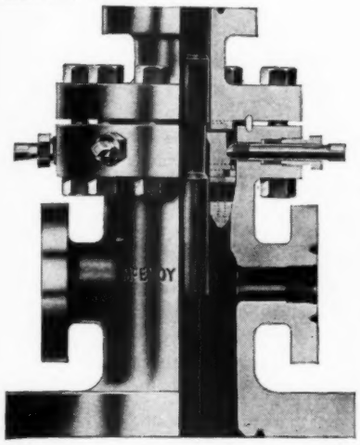
This liner is made by a new process in which perforated steel sheeting is rolled to exact size and welded, forming a strong steel tube with more actual open area per square inch than ordinary screens. Extra strong construction prevents collapse and provides for rigid alignment in the hole even under severe conditions, it is stated. The large open area gives increased permeability for maximum oil recovery. The smooth outer surface of the screen makes installation as easy as running solid pipe, and perfect roundness maintained at every point virtually eliminates the possibility of tearing or catching the screen, it is pointed out. The annulus around the inner slotted pipe is pre-packed with gravel of any desired size. This filtering area reduces sand content of the oil to a minimum, helps prolong pump life, and increases recovery efficiency.

Pacific Perforating Company manufactures pre-packed gravel liners in all popular lengths and diameters, ready for installation. The liners can also be made to meet special well conditions, if desired.

For complete information, write direct to Pacific Perforating Company, Torrance, California.

McEvoy Type ATSC Tubinghead

A NEW high-pressure tubinghead featuring a special hanger to permit running and landing tubing through the Christmas tree has been announced by McEvoy Company, Houston, Texas.



The new head, known as the McEvoy Type ATSC Tubinghead, can support the longest strings of tubing safely, the manufacturer asserts. It saves time at a critical period during completion because tubing collars and hanger nipple may be run through the Christmas tree under full pressure control at all times, it is stated. Tubing may be raised any distance off bottom after the packer is set and locked in place by means of set screws in the flange of the head.

Extra-thick, oil-resistant packing is used to insure a perfect seal between strings at all times. Should reworking become necessary, the tubinghead bonnet can be removed and blowout preventers installed for complete removal of tubing. The new head is available to 10,000-lb. test pressure.

Simplex Lightweight Emergency Jack

TEMPLETON, Kenly and Company, 1020 South Central Ave., Chicago, Illinois, have placed on the market a new lightweight, single-acting, automatic raising and lowering emergency jack, which is designated No. 522.

This jack is identical to the Simplex No. 310A Emergency Jack that has a 15-ton capacity, except that it is proportionately smaller and has a capacity of 5 tons, meeting the demand for a smaller emergency jack having all the features of the larger jack.

The No. 522 tilts on its base, when the base pawl is disengaged, permitting angular jacking or pushing and pulling. It lifts on the cap, the auxiliary shoe, the toe lift, and at any intermediate point by using the 4½-ft. 7/16 BBB chain, which is fitted with a grab hook, as a sling.

It has a large, strong inner-ribbed base, a double lever socket for operation in close quarters, and the toe lift is machine-corrugated. The No. 522 has the Simplex "Gold Medal Award for Safety" mechanism and is made of the same long-lasting, heat-treated parts used in the larger No. 310A.

The No. 522 weighs 64 lb., 44 lb. less than the No. 310A, is 22 in. high, has a 14-in. lift.

ACTUAL RECORDS show that a California operator is getting as much as 100 feet *more hole* per bit through certain formations after installing the new Martin-Decker "Sealtite" than with the worn, inaccurate instrument used previously.

Add extra footage like that to your log and see how you save on expensive round trips . . on bit costs . . on drilling time!

FIELD FACTS *Prove* "SEALTITE" BOOSTS BIT EFFICIENCY

With a weight indicator that has plenty of "snap" you get a *constantly accurate* picture of weight variations. You can maintain, *continuously,* the exact weight that gives the most efficient drilling action. You can make hole faster . . drill straighter . . and get more footage from every bit you run.

Complete Drilling Control!

To make sure of getting top-notch performance all the time, install the new Martin-Decker "Sealtite" Drilling Control Instrument. With it you can control *every* phase of drilling—at *any* depth, in *all* formations. It is built for accuracy under all conditions. It's leakproof . . requiring no attention . . and is instantly ready for work. It indicates, *and simultaneously records,* weight, mud pressure and torque, and shows rotary table speed. The illuminated weight indicator has vernier accuracy for lightweight operations, yet capacity to handle loads greater than thus far encountered. Compact, easy to install and absolutely dependable on all jobs.

Get the most from your drilling dollars. Start now to cut costs with Martin-Decker "Sealtite" Drilling Instruments. There's a type and size to fill every need. Contact your nearest representative today for full details . . . or write direct.

HOME OF THE WEIGHT INDICATOR

MARTIN DECKER CORP.

LONG BEACH, CALIFORNIA

SAN JOAQUIN VALLEY: A. F. McQUISTON, BAKERSFIELD, CALIFORNIA

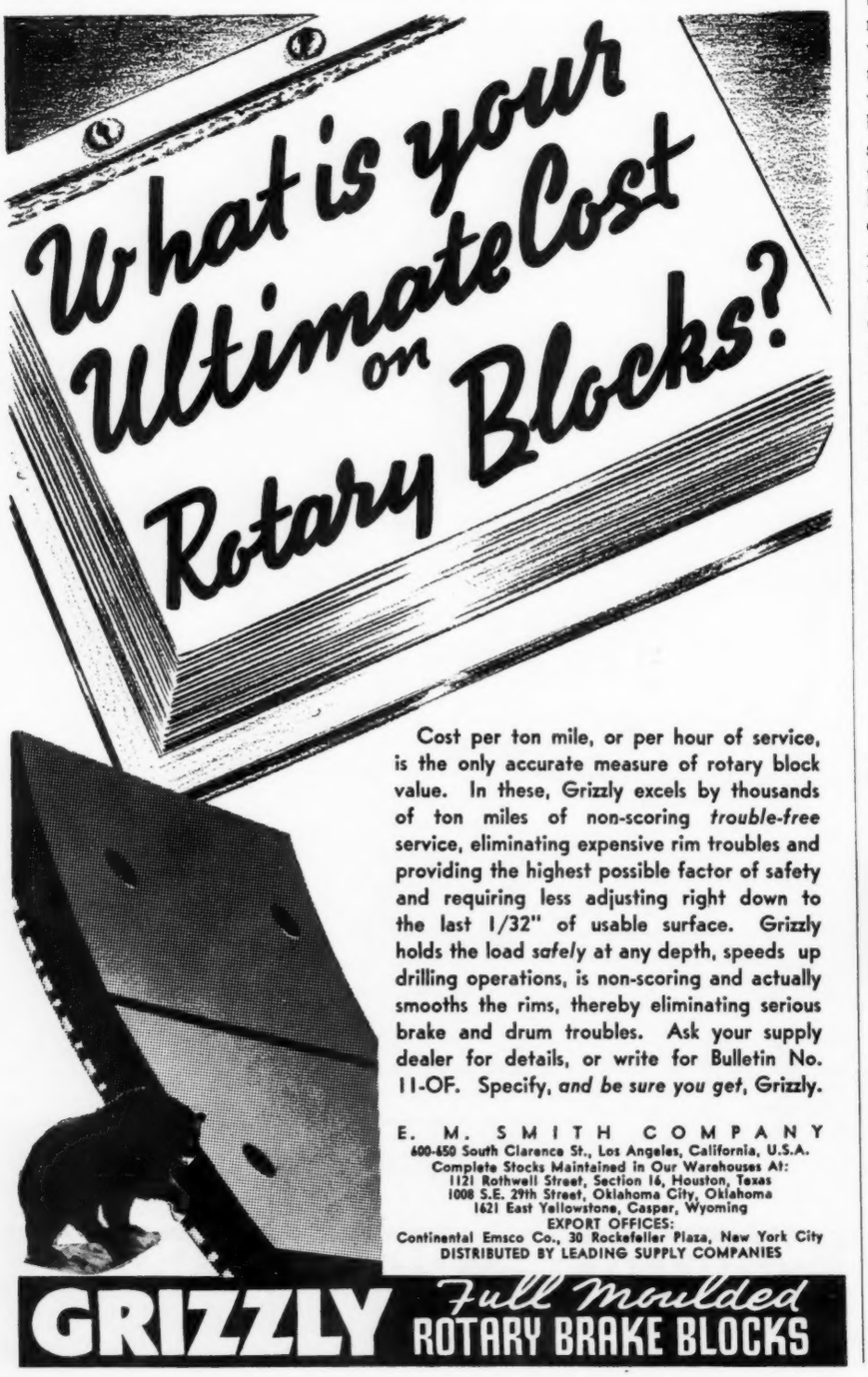
MID-CONTINENT DISTRIBUTOR: REED ROLLER BIT COMPANY, HOUSTON, TEXAS

Merco Concentrator For Maintaining Mud-Weight

IN drilling operations, the factor of maintaining rotary drilling mud at its proper weight usually entails a considerable waste of costly weighting material. When rotary drilling mud picks up colloids, it becomes thick and viscous. To reduce this viscosity, water must be added, which results in a lessening of the mud weight. More weighting material must then be added to the diluted mud to restore it to the desired weight. Due to this addition of water and weighting material, the volume of mud is increased and a disposal of the surplus weighted mud becomes necessary. If the mud, however, accumulates gas and water, its viscosity and weight decrease. This, likewise, requires the addition of weighting material and the discarding of the surplus volume of weighted mud.

The new Merco Type A-24 Concentrator has been specifically designed and perfected to maintain mud-weight without the needless waste of surplus weighting material, the manufacturer states. The Merco Concentrator is installed adjacent to the mud ditch, where it takes off a small portion of previously desanded mud (from 10 to 25 gal. per min.). This may be diluted with 1 to 2 parts of water. The diluted weighted mud is then centrifuged and the weighting material concentrated in the underflow, from where it is remerged with the circulating mud stream. The colloids, gas, and excess water are decanted in the overflow of the Merco Concentrator and go to waste. Any desired concentration may thereby be obtained to a density of 120 lb./cu. ft. It is not necessary to operate the concentrator continuously, but only so long as the weight of the mud from the well is decreasing or the viscosity is increasing. If it is desired, the mud weight can be reduced by diverting weighting material to storage. Upon completion of the well, the residual mud can be treated for reclamation of the weighting material in a highly concentrated fluid for storage or further use. The new Merco Type A-24 Concentrator differs from the Merco Type A-24 Desander in application and construction. The Merco Concentrator is designed for concentrating mud-weighting material, whereas the desander is designed for extracting sand and cuttings from the mud. The concentrator is constructed for much higher speed and has other refinements not embodied in the desander.

A new bulletin, No. X-244, is available with flow chart, describing this new machine. It may be obtained by writing Merco Centrifugal Company, 343 Sansome Street, San Francisco, California.


What is your Ultimate Cost on Rotary Blocks?
Cost per ton mile, or per hour of service, is the only accurate measure of rotary block value. In these, Grizzly excels by thousands of ton miles of non-scoring *trouble-free* service, eliminating expensive rim troubles and providing the highest possible factor of safety and requiring less adjusting right down to the last 1/32" of usable surface. Grizzly holds the load *safely* at any depth, speeds up drilling operations, is non-scoring and actually smooths the rims, thereby eliminating serious brake and drum troubles. Ask your supply dealer for details, or write for Bulletin No. 11-OF. Specify, *and be sure you get*, Grizzly.
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600-650 South Clarence St., Los Angeles, California, U.S.A.
Complete Stocks Maintained in Our Warehouses At:
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DISTRIBUTED BY LEADING SUPPLY COMPANIES
GRIZZLY Full Moulded ROTARY BRAKE BLOCKS

Improved Skinner-Seal Collar Leak Clamp

M. B. SKINNER Company, 3502 West Sample Street, South Bend, Indiana, announces an improved Skinner-Seal Collar Leak Clamp. Retaining the "Sealed Gasket" principle, from which their "Skinner-Seal" trade-mark is derived, the clamp has been made heavier than before, and simplified for easier application, the gasket container ring now being equipped with bolts (same size as pull bolts) instead of cap screws.

A handy socket wrench for applying clamps is enclosed in each carton of three clamps.

MacClatchie Announces Wall Cutter

MacCLATCHIE Manufacturing Company, Compton, California, has announced development of the MacClatchie 3-Cone Wall Cutter, especially made for enlarging the hole below the shoe to facilitate running pipe, cementing, and performing other well-completion operations.

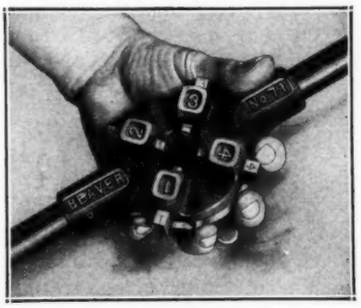
Similar in cutting action to a roller bit, this tool starts a formation shoulder around the circumference of the hole, rides on top of it and cuts the formation completely away, increasing the diameter of the hole 2 in. Completely stabilized and centered, the cutter smoothes-out irregularities in the wall of the hole and removes formation broken by the drilling bit, it is stated. The 2-in. increase in diameter obtained is ample to make liner setting, cementing, etc., easier and quicker.

The 3-cone cutter consists essentially of three arms equally spaced on the body, with a rock bit cutter on the end of each. Circulation ports behind the cutters and through the tool keep the cutters clean and permit full circulation to be maintained.

Full particulars can be obtained by writing direct to MacClatchie Manufacturing Company, Compton, California.

No. 71 Beaver Pipe and Bolt Threader

THE new No. 71 Beaver Pipe and Bolt Threader, illustrated herewith, threads pipe from ⅛ in. to ¾ in., right or left hand, and bolts of ¼-in. to 1-in. diameter, right or left hand, coarse or fine thread; American or British standard threads. More than 100 kinds and sizes of dies are available. The die bosses project far above the face of the tool body so that chips clear instantly; even the long curls from soft-steel bolt stock cannot clog or jam the tool, the manufacturer asserts. The dies are easy to oil, a factor essential to good threads and long die life. A self-centering universal chuck eliminates loose bushings. The tool is suitable for use with modern power units or for hand use. A sturdy metal box having hinged cover and partition to hold 12 sets of dies is available as an accessory.



Further information can be obtained from Beaver Pipe Tools, Inc., Warren, Ohio.

A major oil company operating in foreign territories not affected by war requires from time to time fully trained and experienced personnel for oil refinery and oil producing operations. Qualified candidates are invited to forward experience records in detail including age, education and citizenship.

Some of the specific requirements are for:

ENGINEERS
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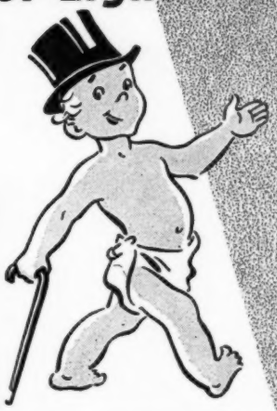
Address Box 12 c/o The Petroleum Engineer
Allen Building Dallas, Texas

Last Year's Infant Prodigy Steals the Spot-Light Again!



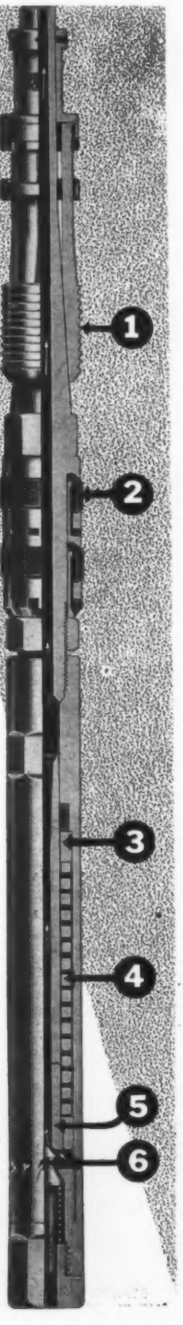
NEW TYPE VALVE

PERMITS PUMPING THROUGH OTIS REMOVABLE BOTTOM HOLE REGULATOR . . .

One of the most popular new tools made available to the oil industry last year was the Otis Removable Bottom Hole Regulator. In five short months it was a "must" in more than 40 producing fields. It is in such high favor because it adds surface-controlled rate of production to the advantages of bottom hole choking; it reduces highest tubing flowing pressures to safe workable limits and it *positively eliminates freezing* of surface controls, doing away with costly heating plants.

And *now*—there is another advantage to using the Otis Removable Bottom Hole Regulator. The new type valve enables you to pump *down* through it if it becomes necessary to kill the well while the Regulator is in the tubing. In the usual operation, a movable valve seat is urged against a valve by a heavy coiled expanding spring. Well pressure against the movable valve seat, less the area of the valve, raises the valve seat to permit flow up through the orifice in the valve seat. To allow reverse direction of flow, the valve moves down, instead of the valve seat moving up.

WRITE OR CALL TODAY. Look in the yellow pages of your telephone directory under "Oil Field Service" for nearest Otis representative.



1. Slips 3. Adjusting Ring 5. Movable Valve Seat
2. Sealing Cups 4. Expanding Spring 6. Valve

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DALLAS, TEXAS
Branches: Oklahoma City, Okla.; Houston, Texas; Hobbs, N. M.
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ON THE RECORD

HOSE B—4" SIZE
In service, 31 months
81,000 ft. of Hole Drilled
*TOTAL HOSE COST
1 1/10 Cents
per foot of hole drilled

**Including purchase price and upkeep*

LAST LONGER

The life of Chiksan All-Steel Rotary Hose is not shortened by age or climatic conditions. Chiksan Hose is light in weight, too. Compare it with others you see for yourself.

4", 5" DRILLING HOSE
3" for Standby and pressure service
45', 50', 55', 60' Lengths

Gulf Engineers, Inc., Distributors in Texas, Louisiana, Arkansas and New Mexico.

Well Equipment Mfg. Co., Distributors in Oklahoma and Kansas.

BUY THE HOSE THAT FITS YOUR PUMPS

CHIKSAN BALL BEARING SWING JOINTS

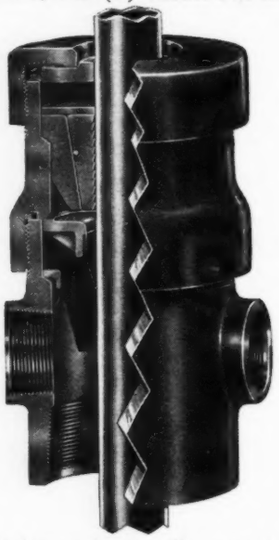
CHIKSAN TOOL COMPANY
BREA, CALIFORNIA

BALL BEARING SWING JOINTS for ALL PURPOSES
ALL-STEEL ROTARY HOSE
CIRCULATING HEADS • MUD GUNS
THREE-WAY DISC BIT
STANDARD AND HEAVY DUTY REAMERS

Larkin Interchangeable Tubinghead

A NEW interchangeable tubinghead recently announced by the Larkin Packer Company, 6200 Maple Avenue, St. Louis, Missouri, has many unusual features in design and assembly.

Five basic types are available: (1) Model SR with blowout preventer for high-pressure work; (2) Model R regular slip-type head for low-pressure or pumping wells; (3) Model M mandrel type head; (4) Model FR flanged slip-type head, and (5) Model FM flanged



mandrel-type head. All parts for one head will fit any other because they are made with jigs that insure absolute precision in manufacturing, the makers state. The head body can be threaded for either 5½-in. O.D. or 7-in. O.D. casing and all parts of heads threaded for 5½-in. O.D. can be used on heads threaded for 7-in. O.D. Internal construction is such that the inside diameter is the same as that of the pipe on which the head is run so that any packer or tools that will run in the pipe will go through the head.

The Model SR head is equipped with a neoprene stripper and blowout preventer designed to hug the tubing closely so that the tubing can be run under considerable pressure.

All models are supplied ready for use, with choice of internal parts for either 2-in. or 2½-in. regular or external-upset tubing. Any model equipped to run 2-in. tubing can be adapted quickly and easily to run 2½-in. tubing by simply changing slips, slip bowl, stripper, rubbing packing, or tubing hanger. A 2½-in. model can likewise be reduced to run 2-in. by merely installing 2-in. parts.

Because of the forged-steel construction, the head and all parts test to 4500 lb. cold hydrostatic pressure, providing a high safety factor.

The head body proper is precision drop-forged from a steel billet, and has forged outlets. All steel parts, from top gland down through the body, are steel forgings engineered for heavy-duty service. Complete absence of welding or riveting operations in the construction of this head eliminate entirely the possibility of breakdowns or leaks, the manufacturer asserts.

The flange-type tubingheads (models FR and MR) have rated working pressures as follows:

Top flange:

12½ in., 1-7/16 in. thick, 12 bolts ¾ in.—500 lb.

12½ in., 1⅝ in. thick, 12 bolts ⅞ in.—1000 lb.

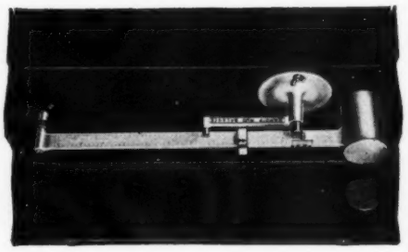
14 in., 1⅞ in. thick, 12 bolts 1 in.—2000 lb.

15 in., 2⅛ in. thick, 12 bolts 1⅛ in.—3000 lb.

Overall height of Model SR is 18 in. Models M and R are 13 in. high. Flange-type heads are 14½ in. overall height. These low overall heights are especially desirable when it is necessary to confine the height of a Christmas tree, it is pointed out.

Carrying Case for Baroid Mud Balance

A TWO-PURPOSE metal case has been designed for carrying the Baroid Mud Balance and also to act as a protection against wind and rain when determining the density of drilling fluids with the balance. An especially designed catch holds the cover



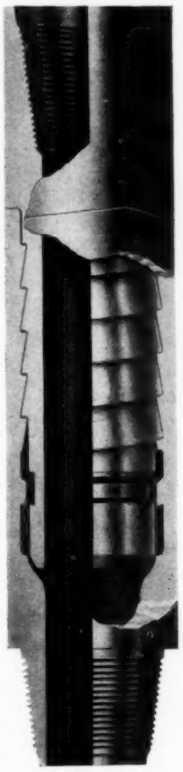
straight up as indicated in the illustration and prevents wind from disturbing the natural oscillation of the sensitive balance during a test.

When not in use the upper section of the balance is removed from the base and clamped securely into place. The base is attached to the case in working position by thumb screws. Inasmuch as the Baroid Mud Balance is alumilited, the case has been finished in dark green to provide a suitable neutral background and thereby make it easier to read the calibrations on the balance arm.

These cases are available with or without the mud balance. Prices can be obtained from the Baroid Sales Department offices at Los Angeles, California, Houston, Texas, or Tulsa, Oklahoma.

Safety Joint Announced By Bowen

A RECENT addition to the line of Bowen fishing tools and specialties announced by S. R. Bowen Company, Santa Fe Springs, California, is an improved safety joint for use in the drilling or fishing string. This joint has a number of special features that contribute to safety and positive operation regardless of drilling or fishing conditions.



Simple construction and "foolproof" operation are important features of the joint. They insure the user that the string can be disconnected quickly at the joint, and that he can reengage it at will, the manufacturer asserts. The tool has only two steel parts —a pin and a box section — and is equipped with high-pressure packer rubbers that seal-off fluid inside and outside the string under any pressure. Outside diameters and fluid passages on all joints are the same as tool joints of corresponding sizes, thus in no way interfering with the running of wire-line instruments, etc., through the drill pipe.

Another important feature of the Bowen Safety Joint is that nothing but definite mechanical action, controlled by the operator, will cause it to come apart in the string, it is stated; in fact, the joint is so constructed that rough drilling or excessive vibration actually tend to make the tool up tighter. Bit or drill collar inertia while rotating out of the hole will not affect the make-up of the joint. The halves are in constant tight engagement, permitting no wear, it is stated.

The Bowen Safety Joint is made of selected alloy steel, properly heat-treated to withstand greater tensile or torsional strain than the string with which it is used, according to the makers. The tool requires only periodic inspection.

Complete information on the Bowen Safety Joint can be obtained by writing to S. R. Bowen Company, Santa Fe Springs, California.

SEALING PRESSURES SINCE 1888

For severe service conditions leading manufacturers turn to COOK'S "custom made" PISTON RINGS

COMPARE THESE FEATURES

- **COOK'S GRAPHITIC IRON** —a superior wear resisting and wear retarding exclusive ring material.
- **ALLOYED IRON**—for special conditions.
- **TINIZING**—an exclusive non-scuff, anti-friction surface treatment.
- **COOKMET**—a plastic bronze in many mixes for use where non-ferrous rings are indicated.
- **NON-METALLIC**—for use where this property is essential.
- **DESIGNS**—all conventional styles and numerous special types.

***because they have* LONGER LIFE *and* REDUCE CYLINDER WEAR**

ENGINEERS know that it takes more than ordinary piston rings to stand up in severe service equipment—equipment in which lubrication is generally poor because of extremes of pressures and temperatures and because the nature of the gas is destructive to lubrication . . . They realize that it takes rings of special design and special materials . . . That's why so many turn to COOK'S Rings, for COOK'S comprehensive line includes types and materials "Made to order" to meet these specific conditions.

Take a tip from these leading manufacturers . . . Turn to COOK'S Rings and cash in on the savings that invariably result from long ring life and reduced cylinder wear . . . Submit your piston ring problems to us . . . COOK'S engineers will produce the ring for the job.

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Piston Rings

1 SEAMLESS
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6 ENDS MARKED IN QUARTERS
7 COMPLETE IDENTIFYING MARKS ON EVERY FITTING
8 A FULL LINE
YOU pay no more for the welding fittings that alone combine these eight features.
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Seamless Pipe Fittings for Welding
TAYLOR FORGE & PIPE WORKS
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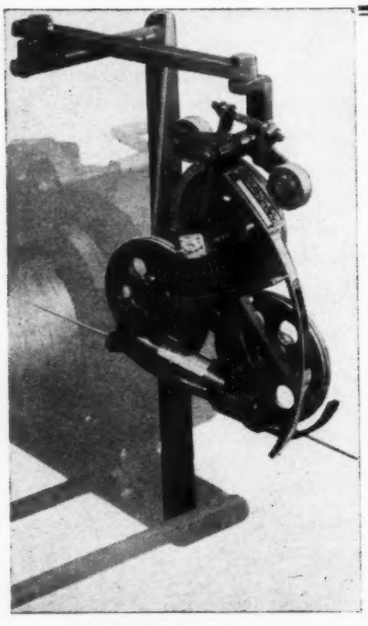

MATHEY Measure Meter and Weight Indicator

Mathey PORTABLE MEASURING UNITS

For any depth work, with reel capacities from 5,000 feet to 15,000 feet of .072 line. Seven models are available for mounting in trailers, cars, pulling-units, and core drills. Self-powered by gasoline engine or power take-off models.

MEASURE METER and WEIGHT INDICATOR

This new measuring device eliminates the factor of human error in well measuring operations, by indicating, on easily read dials, the weight and length of line in the hole.

The Type B Measure Meter and Weight Indicator is adaptable to all units using measure meters. It is built for any size measuring or torpedo line.

Write for Descriptive Literature

Gas Testing Equipment — Measuring Meters
Reeling Equipment for Well Shooting
Oxy-Acet Pipe Beveling Machines
Designers, Manufacturers of Special Machinery
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C. A. MATHEY MACHINE WORKS

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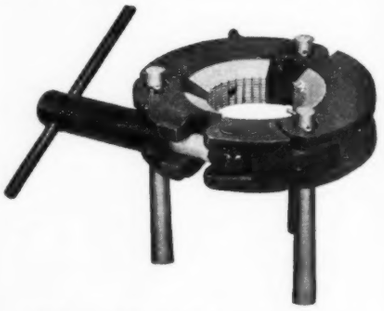
Drill-Collar Clamp for Flush Pipe

POIST Tool Company, 2750 Cherry Avenue, Long Beach, California, has introduced a drill-collar clamp called Griplok that provides, according to the manufacturer, an unyielding grip on the pipe collar or liner. It is



applied to the pipe before breaking-out the joint. Griplok is an adjustable clamp consisting of four steel segments held together by three tapered pins, and locked with a tie-bolt. It is self-adjusting and is equipped with interchangeable slips that fit all sizes of pipe. It can be locked in 30 seconds. A convenient tie-bolt cinches the inserted slips, and stress is evenly distributed throughout the pipe's periphery. The three long tapered pins serve a useful purpose. If the pipe falls, due to dull or worn slips, or from any other cause, the pins, striking the table slips, tighten the device. At the same time they help to absorb the shock of the drop and also tighten the cinch of Griplok around the pipe. This device is placed a few inches above the rotary table slips. Further information may be obtained from the manufacturer.

Robinson Meter-Leveling Saddle

ANNOUNCEMENT is made by Robinson Orifice Fitting Company, Los Angeles, California, of the development of a new meter-leveling saddle. It consists essentially of three

parts—saddle, collar, and U-bolt. Ingenious design and construction permits the saddle, by virtue of a three-point landing, to adjust itself to all variations in pipe roughness, and allows

a leveling arc of 14 degrees, the manufacturer states. Slotted U-bolt grooves eliminate the difficulty of unscrewing the U-bolt nuts from rusty threads. The tops of the U-bolt slots in the saddle, however, are machined at an angle to eliminate the possibility of the U-bolt coming loose from the saddle.

The threaded leveling collar is interchangeable with all sizes of saddles. In use, one piece of 2-in. pipe direct from the meter-leveling saddle to instrument affords a symmetrical set-up and eliminates flange and nipple. Robinson meter-leveling saddles are available for installation on pipe sizes 2 in. to 16 in. For full details address the manufacturer, Robinson Orifice Fitting Company, 1435 Santa Fe Avenue, Los Angeles, California.

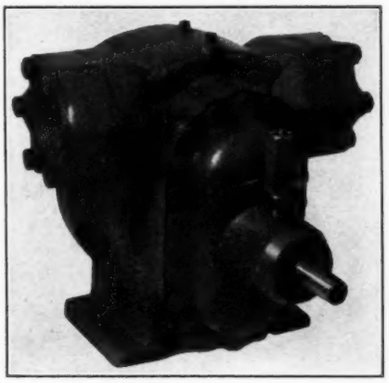
Smith Butane Pump

THE Smith Precision Products Company, South Pasadena, California, is introducing the new Smith Butane Pump.

High volumetric efficiency, elimination of bearing loads, and the provision of a packing box permanently sealed against the escape of volatile gases under extreme pressures are the principal features of this new Smith design.

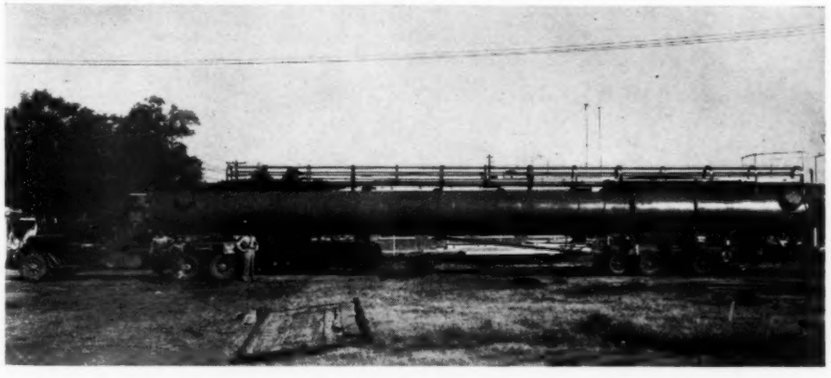
The Smith Butane Pump is a multiple-gear-type pump, in which each gear is provided with double inlet and outlet parts, diametrically opposed, in such a way as to relieve or balance entirely the shaft bearing loads. Reduction gears placed within the pump housing permit direct motor drive. The integral reduction gear case is filled with a lubricating fluid that is of heavy consistency and insoluble in butane. This fluid is readily retained by the packing box and thus entirely prevents all possible escape of butane vapors around the shaft, it is stated.

The Smith Butane Pump is ruggedly built to withstand high pressures and hard service, such as that incidental to

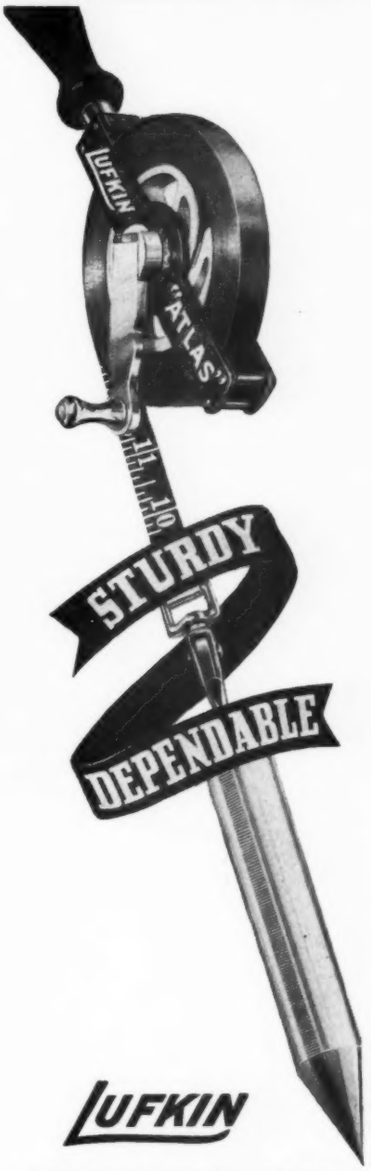


tank filling without vapor return, and has application for all butane-propane installations, the manufacturer asserts. Capacities of 30 to 80 gal. per min. are provided for, depending upon the customer's requirements and installation conditions. Working pressure of the pump is 250 lb. Static tests are applied at factory to all pumps to insure an adequate factor of safety and freedom from leaks, the makers state.

Absorber Fabricated for East Texas Plant



Shown here is an absorber fabricated by the J. B. Beaird Corporation, Shreveport, Louisiana. This vessel was designed by The Hudson Engineering Company, Houston, Texas, for the Hercules Gas Company at Kilgore, Texas. The picture was made of this 54,000-lb. absorber as it left the Beaird plant at Shreveport for its 75-mile trailer trip to the refinery at Kilgore. This absorber is 5 ft. I.D. and has a straight shell length of 73 ft. The shell is made of 11/16-in. firebox quality steel plate. There are 22 trays made of steel plate having cast-iron bubble caps.



LUFKIN

"ATLAS" STEEL TAPE

The world's best and most durable Oil Gaging Tape, the Lufkin "Atlas", known everywhere for its accuracy and ease of use.

The extra tough half inch line is mounted on a staunchly built case-hardened frame. The lock handle with large finger knob and the oversize drum shell give good grip and speed in winding.

WRITE FOR CATALOG 12-A

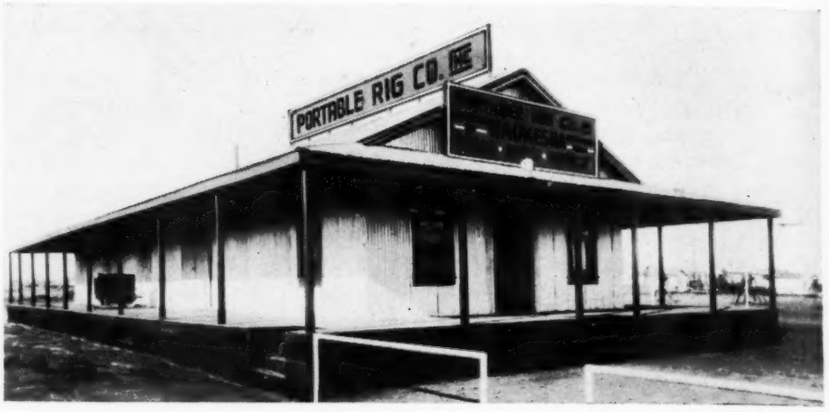
LUFKIN

SAGINAW, MICHIGAN • New York City

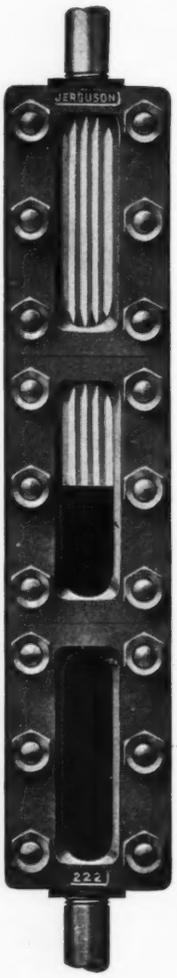
TAPES · RULES · PRECISION TOOLS

Portable Rig Opens Odessa, Texas, Branch

Portable Rig Company, Houston, Texas, has opened a sales and service branch office at Odessa, Texas. Customers in the West Texas-New Mexico area will be served from this store, which carries a representative stock of parts for portable-drilling equipment and all models of Waukesha engines. Factory-trained service men are available night and day.



JERGUSON



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are preferred by the Oil Industry because of their reputation for maximum efficiency at all temperatures and pressures.

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LIQUID LEVEL APPEARS
BLACK

Ideal for tanks, towers, stills, etc., carrying gasoline, kerosene, oil, no matter what the color of the liquid. Furnished with or without valves for every type of service.

When you need to show the color and density of liquids, use Jerguson Transparent (thru vision) Gages.

Jerguson Gages are Best
By every real test.

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JERGUSON GAGE & VALVE CO.

89 FELLSWAY
SOMERVILLE MASSACHUSETTS

Look for the *Arm-and-Hammer*

ARMSTRONG BROS.

Improved
PIPE CUTTERS

The Drop-Forged and "Combination" Pipe Cutters can be used as a 1 or 3 wheel cutter. All are improved cutters, accurately made with hardened steel pins and rollers. Thrust rods of "Saunders" type cutter are hardened at the point and bear on embedded, hardened steel block. On "Barnes Type," the thrust is taken up by drop-forged steel sections. Parts are interchangeable with other standard makes. All are Cadmium Plated.

ARMSTRONG BROS. Knife Blade Cutter Wheels cut much faster and easier, hold their keen cutting edge, for they are made of Vanadium Tool Steel, heat treated, hardened, and cadmium plated.

Write today for Catalog C-39, showing the most complete line of Pipe Tools made.

ARMSTRONG BROS. TOOL COMPANY
"The Tool Holder People"
331 North Francisco Avenue
CHICAGO, U. S. A.

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